RADIO and ELECTRONICS

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RADIO and ELECTRONICS

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OUR COVER

This month our cover picture shows some of the instruments referred to in the article on page 13, on Westrex's new test equipment set-up.

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The Editor,
"Radio and Electronics,"
Box 22,
Government Buildings P.O.
WELLINGTON.

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OFFICES AND LABORATORY:
Radio and Electronics (N.Z.) Ltd.,
46 Mercer Street, Wellington.

TELEPHONE:
Wellington 44-919.

AUCKLAND REPRESENTATIVE:
Mr. J. Kirk,
No. 11 Keans Building,
150 Queen St., Auckland.
Telephone 48-113. P.O. Box 401.

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THE IMPORTANCE OF TECHNICAL INFORMATION

In a small country like New Zealand, where the amount of fundamental and other research that can be done is severely limited, technical information is one of the most essential imports. This is especially so where a great range of previously imported commodities is now manufactured in the country. The radio industry is a typical example of a secondary industry which has grown to greater dimensions than it could ever have attained had the free importation of overseas goods been allowed to continue. It is not our purpose here to inquire into the reasons for the growth of the industry, nor to express an opinion on the benefits (or otherwise) that may have accrued as a result of the import restrictions, but merely to affirm that, having acquired a flourishing secondary industry, we are dependent upon technical information from abroad for its advancement. Contrary to popular belief, little can be expected in the way of technical advancement in the ordinary domestic radio set as a result of the great advances of technique which occurred during the war. It might appear, therefore, that the importation of the latest technical information is not of immediate importance, but this is not so.

It is a well-known maxim in business that not to progress is ultimately to slip back. What we would like to stress, with as much emphasis as possible, is that the above, although a cliche, is none the less true, and is more so than ever when it is applied to an industry so solidly founded on applied science as is radio. It would be unfortunate, but by no means a calamity, if the quality of domestic radio sets remained for some years at its present level, which is high enough to meet the great majority of the public's requirements for the reception of broadcast programms. Progress in the design of commercial commodities which have already reached a reasonable degree of efficiency is necessarily slow, in any case, through some of the requirements of commerce itself, but it is not the domestic set industry alone to which we refer. What would be calamitous is the stagnation in technical progress that must certainly occur if radio engineers and technicians are starved of new information from overseas.

This can be very effectively illustrated if we consider what could NOT have been done in this country during the war had our technical men not been of high calibre, or had they been unable to keep abreast of modern developments through the reading of up-to-date periodicals and text-books. In this event, it would have been quite impossible for New Zealand to have made the large contributions she did to the allied war effort by designing and manufacturing a great deal of equipment of a highly specialized nature, embodying the results of some of the then most recent research and development work to be done in Britain and America. It is a far cry from the construction of domestic receivers and standard communications equipment to that of micro-wave radar sets, but such was the basic knowledge and adaptability of our technicians and scientists that such radar equipment was successfully designed and manufactured.

For defence reasons alone, it is extremely important that no barrier be placed on the import of technical information, but of almost equal importance is the fact that on information depends all progress. It is apparent that radio and the other branches of electronics will shortly play much more important parts in the daily life of the community than they do to-day, but if the appropriate literature is not obtainable now, such progress will be severely retarded. In our opinion, the matter is of such importance that, however acute the dollar shortage may become, and however necessary it might be to restrict imports from all sources, periodicals and text-books, not only on radio, but in all technological spheres, should always be completely free from import restriction.

AN INSTRUMENT FOR MEARURING "Q" WITH AN OSCILLOSCOPE

That the Q of coils and condensers, the R.F. resistance of resistors, and many other useful radio frequency quantities can all be measured on any reasonably good oscilloscope, with the addition of a small piece of auxiliary equipment is not widely known. This article discusses the principles involved, and describes how the above measurements can be made. A design is given for the necessary additional unit, and curves are provided which enable calculation to be dispensed with.

The measurement of the Q of inductors at radio frequencies is one which is almost universally desired by experimenters and by designers of receiving and transmitting equipment, but for which facilities are not always available. The commercial type of Q-meter is so expensive an instrument that few even among the better equipped commercial laboratories are able to afford one. Also, the standard methods of measuring Q, excepting the former, depend for their success on an accurate standard signal generator, very accurate means of measuring frequency, or on both. Even if this gear is available, the methods are time-consuming and not adaptable to the making of rapid checks, since they tie up in a comparatively complex set-up equipment that may be needed for other purposes.

The method to be described here has several advantages over all these methods. It is not quite so rapid as a Q-meter, but, as against that, it does not require expensive equipment, nor does the accuracy have to be taken on trust, since it can be made as high as desired. With a 3 in. 'scope, it can be as high as 2 per cent., and, with larger tubes, better than this. By means of simple calculations, the R.F. resistance of coils and resistors can be found, to the same order of accuracy. This is as good as, or better than, can be realized even with the best radio frequency bridges—items that are also outside the reach of all but the most lavishly equipped laboratories.

With the auxiliary device described here, measurements may be made at frequencies up to 10 mc/sec., and if a special time-base is constructed there is virtually no frequency limit up to the point where the oscilloscope itself ceases to function properly.

FUNDAMENTALS

The Q of a tuned circuit can be regarded in a number of ways. For instance, it represents the resonant rise in voltage across a parallel-tuned circuit when a voltage is introduced in series with either arm. It can also be looked upon as the ratio of current in each arm to the current drawn from the source of excitation, and in a number of other ways. Qualitatively, it is higher the lower the R.F. resistance of the circuit, and is in some kind of inverse proportion to that resistance. In other words, the greater the losses in a tuned circuit due to such things as the resistance of the wire, the losses in the insulating material, or the losses in a valve or other device connected across the circuit, the lower is the Q. If we have a tuned circuit where all the losses can be regarded as due to the coil, the value of Q is given by the well-known formula:

$$Q = \frac{\omega L}{r}$$

where $\omega = 2\pi f$, f being the frequency in c/sec., and r is the R.F. series resistance of the coil. This equation explains why the quantity Q has become so important in recent years. In order to work out the performance of a circuit of known characteristics, one of the things that must be "known" is the value of r. This is exceedingly difficult to measure directly with any accuracy, but both f and L can easily be

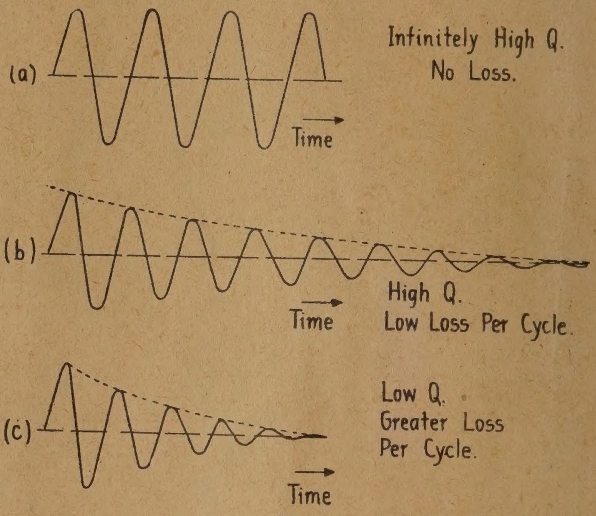


Fig. 1.

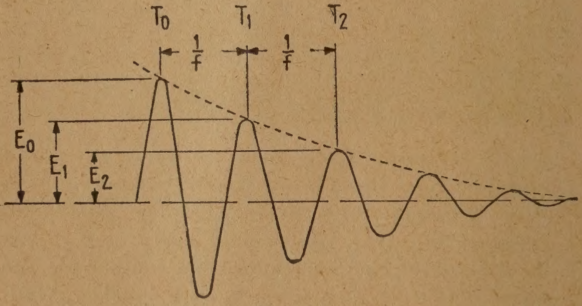


Fig. 2.

measured. So can Q, with the result that r can be found from the above formula, if it is needed. In addition, Q is a very useful quantity which can be used to simplify many important formulae. If means of measuring Q are readily available, substitution methods can be used to find the values of resistors, both low and high, at radio frequencies.

DECREMENT

In the days of "spark" transmitters, the quantity Q had not been invented, and, if it had been, it

would not have been so useful as a quantity known as the "Logarithmic Decrement" of the circuit. This figure, which is hardly ever used to-day, had a direct practical significance when it came to dealing with spark transmitters. In the latter, the radio frequency power was generated by the oscillatory discharge of a condenser through an inductance, such as always takes place if the condenser of a tuned circuit is allowed to discharge with a spark. Now, each spark produced a damped train of waves, similar to those shown in Figs 1 and 2. The frequency of oscillation had nothing to do with the spark, but was dependent upon the frequency to which the oscillatory circuit was tuned, just as is that of a valve oscillator. Now, suppose for a moment that it is possible to have a tuned circuit which has no losses at all. Then, when a spark, or other means, had excited it into oscillation, it would go on oscillating indefinitely, and would, in fact, become a form of perpetual motion. This state of affairs is illustrated in Fig. 1 (a). Since there is no loss of energy, each cycle has the same amplitude as the last. But in a real circuit, however good, there is some loss, and once the circuit has been shocked into oscillation, the amplitude gets smaller and smaller as time goes on. This is illustrated in Fig. 1 (b). The smaller the loss, the longer the oscillation takes to die down, and the smaller is the difference between the amplitudes of successive half-cycles. This is the same thing as saying that the circuit has a high Q. In Fig. 1 (c) is shown a low-Q circuit, whose oscillation dies down comparatively rapidly. When the actual wave-form of a damped train of waves is examined, it is found that the decay of the oscillation follows an exponential or logarithmic law. That is to say, the ratio between the amplitudes of any two adjacent half-cycles is constant. The tips of the cycles fall on an exponential curve similar in shape to the curve showing the discharge of a condenser through a resistor. It can be proved mathematically that if E_o is the peak voltage of the first half-cycle, and E_1 is that of the second, the ratio E_1/E_o is given by:—

$$\frac{E_1}{E_o} = \epsilon^{-tr/2L} \quad . \quad . \quad . \quad (1)$$

where t is the time between peaks, and r is the resistance of the coil. This equation can be written in the form:—

$$\log_{10}\frac{E_1}{E_o} = -\frac{r}{2fL}\log_{10}\epsilon \quad . \quad . \quad . \quad (2)$$

which is more useful, because it is directly usable for calculations. The term $r/2fL$ is the logarithmic decrement, referred to above, and inspection shows that this is equal to π/Q. Thus, by rearranging equation (2), and substituting π/Q for $r/2fL$, we have:—

$$Q = \frac{1{\cdot}364}{\log_{10}\frac{E_1}{E_o}} \quad . \quad . \quad . \quad (3)$$

This equation forms the basis on which the present method of measuring Q rests. All that is necessary in theory is to obtain a picture on the oscilloscope of a damped train of waves from the circuit to be measured, to measure with a ruler the peak amplitude of two successive half-cycles, and substitute the ratio in equation (3).

In theory, the above procedure is quite easy to carry out, but it has the disadvantage of requiring a calculation to obtain the final answer. Also, as outlined, it would give very poor accuracy, especially with high-Q circuits, because here, the difference between the results for circuits of high, but quite widely different Q, is very small.

HOW ACCURACY IS GAINED

It will be remembered that the ratio between any two successive cycles is the same as that between any other two. This fact can be made use of to increase the accuracy of measurement, by a great deal. What this amounts to is that instead of measuring the ratio between one cycle and the next, we find the ratio between one cycle and, say, the tenth or twentieth cycle from it. If we call the amplitude of the half-cycle from which we start measuring E_o, as before, and E_n that of the n^{th} half-cycle from it, we have our final equation:—

$$Q = \frac{1{\cdot}364n}{\log_{10}\frac{E_n}{E_o}} \quad . \quad . \quad . \quad (4)$$

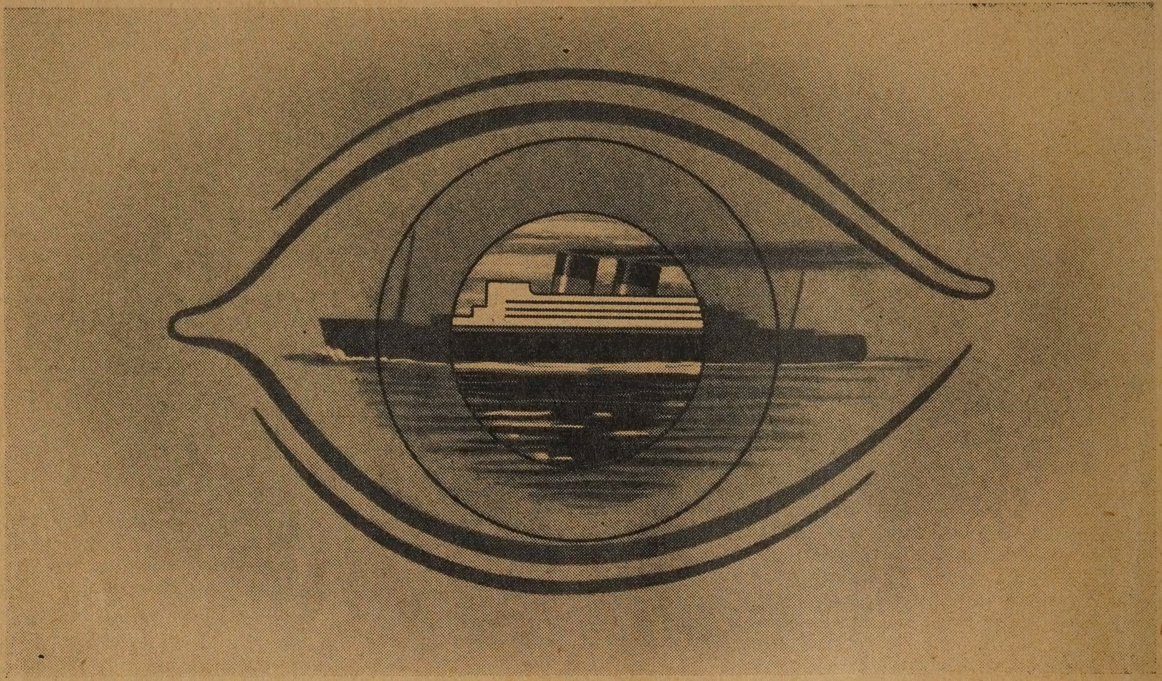
This system is illustrated in Fig. 2, where the amplitudes are shown for E_o, E_1, and E_2. By using a great enough number of cycles, the accuracy of measurement can be made as great as we please, assuming that the oscilloscope picture can be measured accurately enough. For example, if we measure the drop in amplitude at the 40th cycle, and if our measurement of length can be made to within 1 per cent., we will obtain the value of Q to within 3 per cent. for Q's up to 200. In addition, we will be able to measure it to within 4 per cent. for values up to 300, and within 5 per cent. for values up to 500. If we use smaller numbers of cycles, the values up to which these accuracies are obtainable will be smaller. For example, if $n = 20$, we get 3 per cent. accuracy up to a Q of 100, and so on, in proportion. This is illustrated in the curves of Fig. 6, which are given to enable the calculation from equation (4) to be dispensed with.

PRACTICAL CONSIDERATIONS

Having shown in theory how the method works, it remains now to show how it can be put into practice. There are a number of questions which will no doubt spring to mind in this connection. First, how is the tuned circuit to be made to give a damped train of waves such as we have been discussing? How is the picture displayed on the oscilloscope screen? How high a time-base frequency do we need to make measurements at, say, 10 mc/sec., and is the method applicable at frequencies as high as this, anyway? Is there any lower frequency limit to the method? Do we need a specially designed oscilloscope, or will any ordinary one do? These are some of the questions that must be answered if the method is to be regarded as a practical one.

PRODUCING THE DAMPED TRAIN

This is not a difficult matter at all, and its mechanism is readily understood by analogy with a bell, struck by its clapper. In ordinary language we say that when the bell is struck, it rings. Speaking in terms of acoustics, however, we would say instead that the blow with the clapper causes the bell to vibrate at its natural resonant frequency. It thus emits a note which is detected by our ears. Now a parallel-resonant circuit, like the bell, has a natural



resonant frequency, so that if the circuit is given an electrical impulse, corresponding to the mechanical impulse imparted to the bell by the clapper, the circuit will "ring" at its own natural resonant frequency. In this case we cannot hear the ringing, both because it is in the form of an electric current, and because its frequency is too high to be within audible range, even if the electrical vibration were turned into a mechanical one. Instead, we apply the output of the "ringing" circuit to the Y plates of the oscilloscope, and if at the same time we apply a

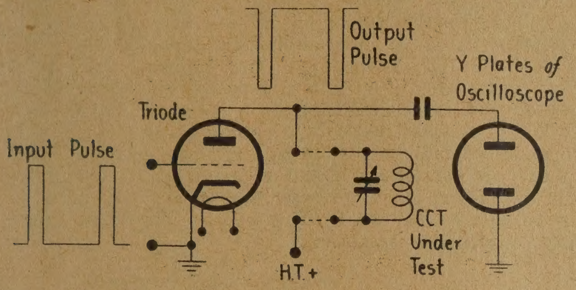


Fig. 3: Showing how the tuned circuit is excited by placing it in the plate of a triode and applying a positive pulse to the grid of the tube. The output of the circuit is fed to the Y-plate of the 'scope, while the X-plate is given a saw-tooth time-base whose frequency is synchronized by the same pulse that excites the tuned circuit. The picture on the screen then shows like Fig. 2b or 2c.

linear time-base to the X plates, we get a graph of the instantaneous value of the voltage across the circuit, against time, exactly as drawn in Figs. 1 and 2. The ringing analogy can be further extended when it is remembered that when the bell is struck, it does not go on ringing for ever, but the intensity of the sound decays quite rapidly. In this case the losses are due to friction between the molecules of the metal in the bell, which causes the initial energy to be dissipated as heat in the material of the bell. Thus, a "high-Q" bell would be one which went on ringing for a long time after it was struck, and a "low-Q" one whose note disappeared rapidly, the striking force in each case being the same.

In the electric circuit, the clapper of the bell is simulated by a sharp pulse of voltage, such as might be obtained by momentarily connecting a battery across the circuit so that a high current flows through the coil for a short time. This procedure would be very inconvenient, however, so instead, the tuned circuit is placed in the plate circuit of a triode, which is normally biassed to beyond cut-off. Then a short pulse is applied to the grid of the valve, which conducts momentarily, and then becomes cut off again. This really gives the circuit two shocks, one when the valve starts to conduct, and another when it becomes non-conducting. At present we will disregard what happens on the first of these, and consider the second. It starts the circuit ringing, and this would go on until the oscillation disappeared. However, at any frequency high enough for us to be interested in, the ringing occupies so short a time that even if it were displayed on the C.R.T., there would be no time in which to observe it. In order to overcome this difficulty, we apply not one pulse, but a series of them, as shown in Figs. 3 and 4. The former shows the system in schematic form, except for the time-base, which is assumed to be synchronized with the pulses fed to the ringing circuit. The pulses are narrow and positive-going when fed to the triode, but are reversed in phase in passing through it. The tube conducts only for the short periods during which the grid is driven positive by the input pulses. The output wave-form of the circuit is given in Fig. 4 (d). It can be seen that the start of oscillations coincides with the sharp rise of plate voltage which occurs when the tube becomes cut off, and that no oscillations are found during the short period while the valve is conducting. The waveform in Fig. 4 (d) is somewhat idealized, in that it is possible for a small oscillation to become started during the latter period, but it is usually quite insignificant, and in any case occurs during the flyback, or should do so if the time-base is locked properly. The main point is that even if oscillations have not died down completely by the time the next pulse arrives, this starts the cycle all over again. At each pulse, the circuit starts ringing in exactly the same manner, so that successive trains start at the same relative time, and have the same initial amplitude. Thus, successive pictures are accurately superimposed, and since the repetition rate is above the threshold of the persistence of vision, the picture appears continuous. The number of cycles shown on Fig. 4 (d) is smaller than would be found in practice, but this is purely for convenience in drawing, and does not affect the argument. The time-base belonging to the oscilloscope can be used, as long as it is

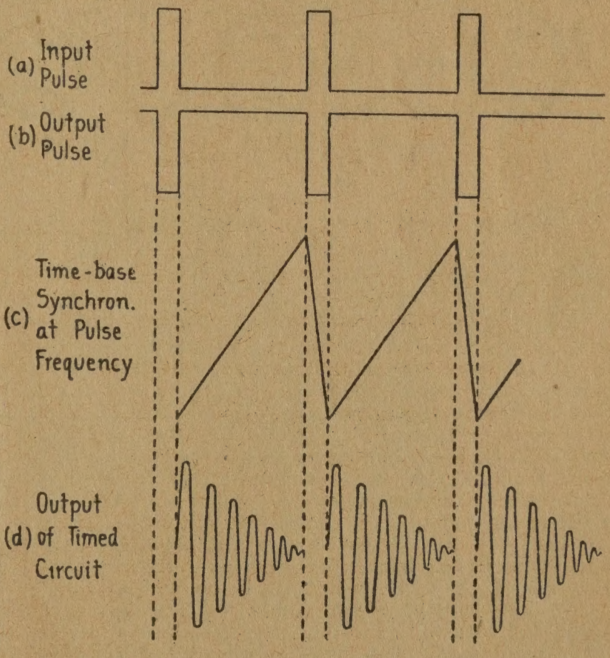


Fig. 4: At (a) is shown the input pulse provided to the grid of the triode (V_3 in Fig. 5). At (b) we have the shape of the voltage pulse produced in the plate circuit. At (c) is shown the linear time-base used to view the output wave-form of the tuned circuit, and at (d) is the wave-form developed at the plate of the triode by the tuned circuit.

synchronized by the pulse that initiates the ringing. This is done by taking a lead from the pulse-forming circuit to the synch. terminal of the 'scope, and NOT from the output of the tuned circuit, for reasons which will appear.

FREQUENCY CONSIDERATIONS

The necessity for accuracy in the final result determines the fact that from 10 to 40 cycles of the damped oscillation must be used in obtaining the measurement, as pointed out above. This, and the lowest frequency at which measurements are required, between them determine the lowest frequency that is needed for the initiating pulses, and, of course, for the time-base. Suppose the lowest radio frequency is 400 kc/sec., and that a high-Q circuit is being examined, thus requiring 40 cycles of the oscillation to be shown on the trace. One cycle of the oscillation will occupy 2.5 microseconds, and 40 cycles will therefore take 100 microseconds. Therefore the trace must last at least as long as this if the full 40 cycles are to be seen. If a 10 kc/sec. time-base and pulse rate are used (neglecting the time taken by the fly-back) one cycle will allow 40 cycles of the R.F. to be seen. Of course, a slower pulse rate can be used if desired, in which case more than the necessary 40 cycles will be seen, but this becomes a disadvantage only when the cycles of R.F. are so closely packed that they cannot easily be counted.

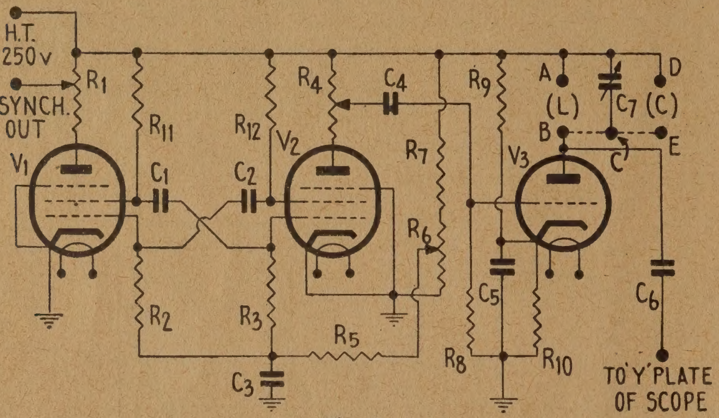


Fig. 5.

It is the latter effect which determines the highest R.F. at which measurements can be taken. Suppose, for the sake of argument, that the greatest number of cycles that can be counted is 20 per inch of trace. Suppose further that the highest time-base frequency available is 20 kc/sec. This is therefore the pulse-rate that must be used. Taking as an illustration an outfit using a 5 in. C.R.T., we can assume that the longest useful trace for our purpose is, say, 4 in. Thus, the greatest number of R.F. cycles that can be displayed so that they can be counted is $4 \times 20 = 80$. Again neglecting the fly-back, this gives us a frequency of 1600 kc/sec. Actually, cycles can be counted at about twice this density, which would indicate an upper limit of 3.2 mc/sec. for this time-base frequency. It will be noted that the above argument assumes that the **whole** time-base occupies the 4 inches of usable space on the face of the C.R.T. If, however, the X amplifier of the 'scope can expand the trace to an amplitude of 16 in., which is not uncommon for a 5 in. tube, the radio frequency could be four times the above figure, i.e., 12.8 mc/sec. Thus, a greater frequency range can be achieved simply by providing more amplification between the time-base and the X-plates of the C.R.T. This scheme obviously has a practical limit, after which it is necessary to use a special high-speed time-base if measurements at higher radio frequencies are to be made.

We have used as illustration an oscilloscope whose time-base has a top frequency of 20 kc/sec., but many instruments have time-bases which will run at much higher frequencies than this. The limiting factor then tends to become the difficulty of making a pulse circuit for exciting the tuned circuit, that runs at a high enough frequency.

The question of whether a specially designed oscilloscope is needed in order to apply the method has been partly answered in the above discussion. Whether it is or not obviously depends upon the design of the 'scope, and the highest R.F. it is desired to use. Even if a comparatively unambitious instrument is available, with a very ordinary time-base and a small C.R.T., it should easily be possible to make measurements up to 5 mc/sec. or more. This makes an extremely useful piece of gear, and gives the experimenter a weapon that could not even be approximated except by the use of a deal of much more expensive equipment.

COMPONENT LIST

V_1, V_2, 6AC7/1852
V_3, 6V6 screen tied to plate
R_1, R_4, R_6, 50k. pot.
R_2, R_5, 100k.
R_3, R_8, 1 meg.
R_7, 50k.
R_9, 25k., 2 watt
R_{10}, 5k., 1 watt
C_1, C_2, 0.001 mfd.
C_3, 1 mfd.
C_4, 0.001 mfd. mica
C_5, 25 mfd. 50v. electro.
C_6, 0.001 mfd. mica
C_7, calibrated condenser (optional)

PRACTICAL EXCITER CIRCUIT

One of the outstanding advantages of this method is the fact that even a separate source of R.F. is not needed, since the circuit under measurement is made to act as its own signal generator. Moreover, the auxiliary equipment which causes it to do so, is simple to construct, and works, even in the most difficult cases, at frequencies little higher than the audio range.

Fig. 5 is a circuit of a practical exciter unit, and is all that is wanted in addition to the oscilloscope. It consists of a multivibrator, which produces the pulses, and the triode of Fig. 3, with terminals to which the coil and condenser of the test circuit can be connected. The output is taken straight from the plate of the triode to one Y plate of the C.R.T., via a blocking condenser, whose function is simply to keep the H.T. voltage away from the deflecting plate. The multivibrator circuit uses two 6AC7's, with the M.V. action going on between control grids and screens. The plate circuit is used as a buffer and extra squarer, and ensures that the output wave-form is really rectangular. The circuit is exactly that used in the linear time-base described in the April, 1948, issue of "Radio and Electronics," except that there is no necessity for any range switching. The lowest

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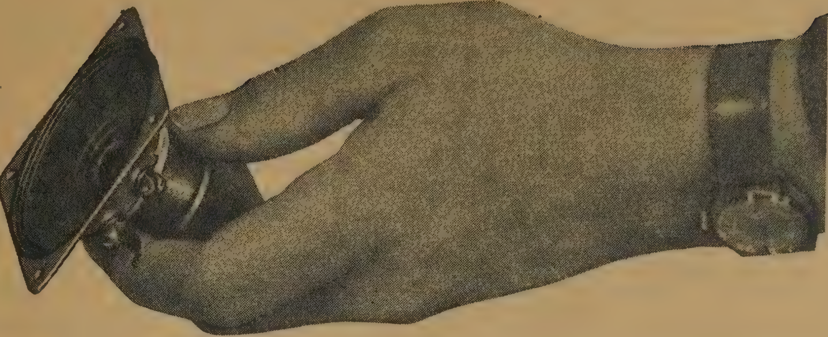
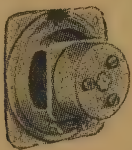


This is the tiny Celestion Model P2V which is 2½ in. in diameter. Compare its size with the watch at right.

Model P2V 2½ in. diameter.



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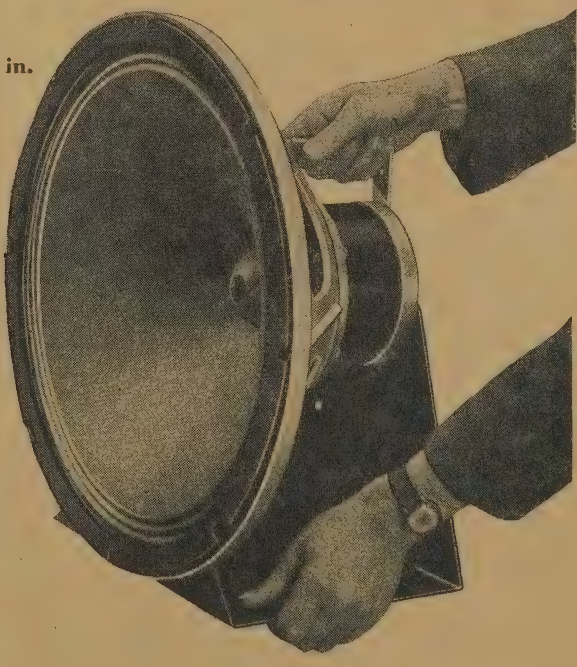
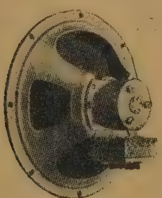
***Model P6Q 6½ in. diameter.**



Model P84 18 in. diameter.

***Model P8D 8 in. diameter.**



***Model P10G 10 in. diameter.**

Model P64 12 in. diameter.

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frequency of the circuit given is about 10 kc/sec., and the highest will be in the region of 50 kc/sec. or higher. The time-constants in the M.V. grid circuits are chosen so that the pulse from V_2 to V_3 will be positive going, and approximately a tenth the duration of the whole cycle. The pulse frequency is controlled by R_6, which acts without altering the mark-space ratio of the output wave. The voltage divider R_8, R_9 places a permanent bias on V_3, high enough for this tube to be cut off at all times except when the positive pulse from V_2 is applied to its grid.

It was mentioned above that an amplifier cannot be used between the output of the tuned circuit and the Y plate of the C.R.T. The reason for this is that there must be a minimum of shunting placed across the circuit to be measured. If there is much shunting, the Q measured will not be that of the circuit alone, but will be that of the circuit with an unknown shunt resistance connected across it. This does not matter when comparative measurements only are wanted, but it would seriously impair the accuracy if an absolute value is required. Thus the amplitude of the damped train would not be controllable if means were not provided for adjusting the excitation voltage applied to the tuned circuit. This control is R_4, which adjusts the amplitude of the pulse feed to V_3. As long as the tip of the pulse does not reach a higher potential than earth (i.e., does not drive the grid of the V_3 positive), the amplitude of the pulse applied to the tuned circuit is under control. R_4 is therefore used to adjust the size of the picture to a suitable amount in the XY direction. The terminals A, B, C, D, and E are incorporated merely for convenience in making a variety of connections. The variable condenser, C_7 is not imperative, but it can be very useful, especially if it is calibrated. Even if C_7 is not calibrated, it is well worth including, for reasons which will appear when we come to discuss the uses to which the instrument can be put. The dotted lines between terminals B, C and E represent jumpers which can be connected for special purposes. Terminals A and B have been labelled (L), as they form the usual connections for an inductor or coil, while terminals D and E are normally used for the connection to the circuit of an external condenser. Three jumpers are required, one to connect B and C, one to connect B, C, and E, and a third to connect B and E, without connecting C as well.

CONNECTION TO THE OSCILLOSCOPE

In most oscilloscopes there is a resistor connected between each deflecting plate and the final anode, which is usually at earth potential. This forms a leak to earth for any electrons which may be caught from the beam, and which would otherwise cause a negative charge to build up on the deflecting plate. Now, when the tuned circuit under test is connected via C_6 to the Y-plate of the 'scope, this leak is shunted across it, causing the measured Q to be slightly less than the actual Q of the circuit. In most 'scopes the value of the leak resistor is 2 megohms, but in order to achieve the greatest accuracy when measuring high Q circuits, the value should be increased to the maximum of 5 megs. The modification will not impair the normal performance of the 'scope in any way.

CONSTRUCTION OF THE UNIT

The construction of the above pulse unit presents no special difficulties. It should preferably be self-powered, and this can easily be accomplished, since the H.T. current will be under 10 ma. The most important thing about the physical lay-out is the provision of short leads in the circuit of V_3. This is because short leads are wanted in the R.F. part of the circuit, which comprises only the tuned test circuit itself. A small unit of the sloping panel variety is a good idea, because this can be made with a wide enough flat top to take the six terminals. The variable condenser can be mounted on the sloping panel, which gives room for a large dial and still allow the leads from the condenser to be made short. A short lead is also desirable between the plate of V_3 and terminal B, so that it is a good plan to mount V_3 upside down, with its socket supported on distance pieces so as to bring the plate pin of the socket close to terminal B. Length of lead in the cathode and grid circuits of V_3 is not important, as these parts of the circuit carry only D.C. or pulse frequency, which is not high.

Power supply regulation is not important, so that any ordinary circuit with a single-section smoothing filter, either condenser-input or choke-input, can be used.

(To be continued.)

GOOD NEWS For Music Lovers

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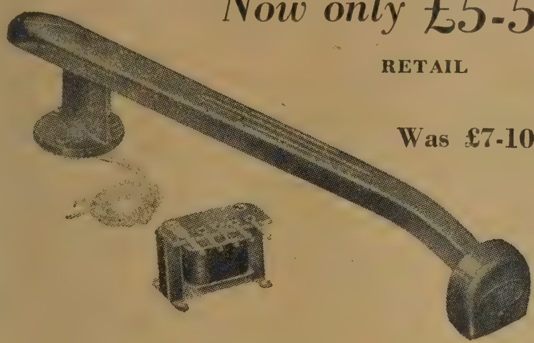

With our last shipment came the good news of this amazing price reduction. Due to the wide public acceptance of this remarkable reproducer it is now being mass produced — and is thus the lowest cost high-fidelity pick-up offering. Get the best from those favourite records.

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Response, as certified by an N.B.S. Recording Contractor, is as follows:—

From 250 to 8000 C.P.S.	± ½ db.
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At 100 C.P.S.	0 db.
At 50 C.P.S.	— 2 db.
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The above gives average output from constant input. Average recordings attenuate approx. 6 db. per octave below 500 C.P.S. Therefore your amplifier needs bass compensation as with all moving-coil and other high-fidelity pick-ups. For use with an ordinary radio, use our special bass boost.

Voice-coil impedance .... 2 ohms

Output from average recordings .12 to .2 volts R.M.S.

Output impedance of transformer .... 50,000 ohms

No Scratch — No Pre-amp. — Lightweight — No Scratch Filter necessary.

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For giving correct compensation for drop in recording levels at the bass end, we now offer the "Sonophone" Bass Boost. Simply lift power tube of radio, plug in adaptor, and re-insert power tube on top. The Bass-boost is small enough to tuck inside the cabinet. State type number of power tube in your set.

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Gain at 30 C.P.S. .... 37 db.

Gain at 50 C.P.S. .... 27 db.

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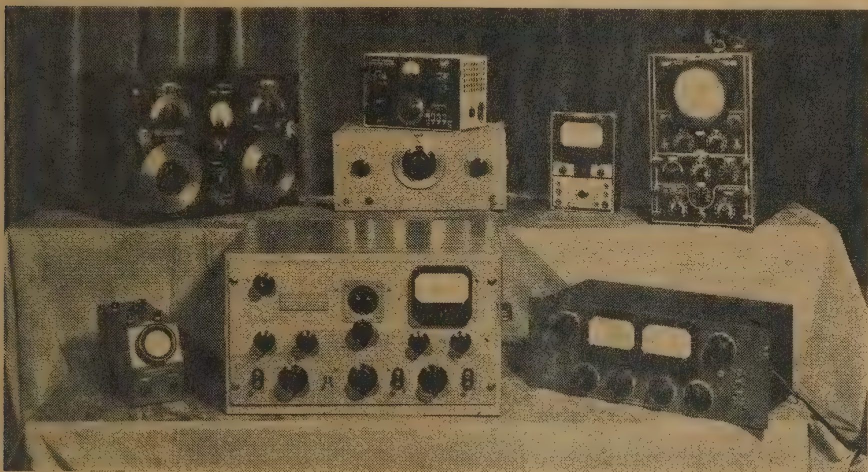
Westrex Sponsor Improved Test Equipment and Servicing Techniques for Theatre Equipment

In a continuing programme to provide modern, up-to-date engineering services to motion picture exhibitors in locations throughout the world, the Westrex Corporation, formerly Western Electric Export Corporation, is providing new post-war testing equipment for use by their field service engineers in servicing motion picture projection equipment and sound reproducing systems.



Some of the instruments described in the text.

To acquaint their field service engineers with the use of the new equipment and with the latest motion picture equipment developments and techniques, Westrex is providing a programme of instruction for all of their national engineers. Mr. E. W. McClennan of the New York Office, engineering expert on motion picture field services, equipment, and testing methods, will arrive in Wellington on the 27th April, 1948, to give intensive courses of instruction, with demonstrations of the use of the equipment and this course will be attended by all the engineers of the Western Electric Co. (N.Z.) Ltd.

The equipment to be used by Western Electric engineers is shown in the photograph above. This array of quality testing equipment was selected by engineering experts as the finest available, and some of the units were especially designed to provide additional facilities not available in existing equipment.

Equipment especially designed for theatre and sound reproduction system testing includes a new portable multi-purpose test meter and a small, lightweight oscillator-gain set for field use.

The Westrex M2 Meter in outward appearance resembles several other instruments of the multi-purpose type, but it has many new and desirable features hitherto unattainable in such equipment. First, the M2 Meter has remarkable accuracy under any of the usual temperature conditions. Not only is the movement temperature neutralized, but precision resistors of the deposited carbon type (a new type circuit element with extremely low temperature coefficient of resistance developed by Western Electric) are used in this instrument. Also a germanium crystal rectifier replaces the usual copper oxide rectifier. This means that the instrument will withstand heavy overloads and high temperatures without damage. One of the greatest difficulties with previous similar designs was that while the movement was rugged and accurate, the copper oxide rectifier would fail and would frequently introduce errors which were difficult to detect or to evaluate in the field. Thus an engineer might use a defective meter for some time without knowing it, causing errors in his adjustment of the system.

The M2 Meter is used for making the many measurements of current, voltage, resistance, and power level necessary in the involved work of checking theatre sound reproducing systems. Complete with a special movement with an unusually high torque-to-weight ratio, the metal-encased M2 Meter provides nine D.C. ranges of from 0–50 microamperes to 0–10 amperes. Available for operation with external resistors is a 0–100 D.C. millivolts scale. Voltage ranges covering both D.C. (at 20,000 ohms per volt sensitivity) and A.C. (at 2,000 ohms per volt sensitivity) include six ranges from 0–2.5 to 0–5,000 volts. Associated with the voltage ranges are decibel scales of -6 to -75 dbm. (decibels referred to a level of one milliwatt), corresponding to ranges of -13.8 to -67.2 decibels referred to a level of six milliwatts (the reference formerly used on decibel scales). Resistance ranges covered are 0–2,000 ohms (12.5 mid-scale) to 0–20 megohms with a total of five resistance ranges. There is provision for higher readings with external battery. An external electronic multiplier will be made available later for extending the ranges of this meter for measurement of smaller quantities.

The Westrex G2 Oscillator-Gain Set provides an audio signal continuously variable over the frequency range from about 30 cycles per second to about 25,000 cycles per second. A feature of this instrument is its extremely small size; it weighs only 6½ pounds and its case measures 6½ by 10 by 6 inches. It consists of an R.C. audio oscillator and a db. meter for transmission tests. Its metered output is measurable as low as one ten-millionth of a watt. The G2 Oscillator-Gain Set is used for calibrating and checking theatre sound systems at the extremely low electrical levels present at the output of photocells.

Other modern servicing equipment available for checking and repairing theatre equipment includes the Hewlett-Packard Model 200-B Audio Oscillator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and Model 330-B Distortion Analyzer. The oscillator supplies audio signals from 20 to 20,000 cps. at 1 watt into 500 ohms. It is used where the small frequency control dial of the G2 Oscillator-Gain Set makes its use impractical; that is, on filters and equalizers whose response characteristics have slopes so steep that small errors in frequency settings cannot be tolerated. The 330-B Distortion Analyzer is a noise and total distortion meter with self-contained vacuum-tube voltmeter, 40 db. voltmeter amplifier, and band-pass filter with passed range continuously variable from 20 to 20,000 cycles. The Brown Engineering Model 200-A Impedance Bridge is supplied for precision measurements of D.C. resistance, capacity, inductance, "Q," etc. It has a self-contained 1,000 cps. source and dry batteries.

The Daven 6C Transmission Set in the lower right-hand corner of the photograph is used in making measurements of gain and loss in amplifier systems. The small cathode ray oscilloscope at the lower left provides the engineers with a portable equipment for viewing electrical waveshapes in their testing and tuning procedures.

The bulkier equipments, such as the 200-B Audio Oscillator, 330-B Distortion Analyzer, 200A Impedance Bridge, and the five-inch cathode-ray oscilloscope, will be located in main offices having shops that do extensive repair work. The G2 Oscillator-Gain Set and certain Academy Standard test films will be available for tune-up and technical inspection, while the M2 Meter will be used by all engineers for routine service work, along with special test films and tools. For emergency work, a new type Westrex Emergency Amplifier can be used to connect between

(Continued on page 45.)

On Doing Justice to Your High-Fidelity Amplifier

This article is dedicated to the numerous music-lovers who have had the all too common experience of building themselves high-quality amplifiers at considerable trouble and expense, only to find that their latest creations sound no better than their previous efforts. This in spite of the fact that they know the new amplifier is a much better job both in design and construction. This is commonly put down as "just one of those things" that are sent to try the unfortunate who is not satisfied with anything but the best. At this stage, two distinct groups appear. First, and perhaps most commonly, our hypothetical builder, knowing that he has considered every detail with painstaking thoroughness, that it delivers its full output with virtually no distortion, and that its pick-up or radio tuner is the best available, slowly (and often quite unconsciously) persuades himself that it really does sound better. Probably it actually does sound a little better, and perhaps a lot better, but still he has the feeling that his ear is playing him false. Representative of the second group, the builder turns on his outfit, listens carefully for distortion (not expecting to hear any) and is amazed to find that his high frequencies are still woolly, his mid-frequencies still harsh, and his bass still boomy. He is probably an old hand, and with the resignation born of long experience, decides that he will have to build another. This time he'll try triodes again, or pentodes, depending upon what his last effort was.

Let us look into this problem a little more carefully. Most of us have heard at some time what we consider to be if not perfect, at least passable reproduction. Now, what was the difference between that outfit and our own? First, it was probably much larger and more expensive. But, as against that, we do not want as much noise in our drawing-room as is required in a large theatre, for example. Thus, by building to a smaller scale, we should be able to produce the same quality. Secondly, most of the better-class installations are found in specially designed studios or auditoriums. In contrast to popular belief, it is a fact that many modern drawing-rooms, furnished with soft carpets and a few drapings such as curtains, tapestries, etc., are almost ideal acoustically for the reproduction of recorded music.

What else is different? Not much is left; theatre music is reproduced from film, the speaker system is bigger and more complicated—there we have it! After all, high-quality theatre speaker systems are quite a long way from what the home builder is able to afford or accommodate. Imagine trying to fit a large wooffer-tweeter combination speaker into a modern drawing-room.

Still, perhaps we may be able to do something about our own speaker system. Let us investigate some of the characteristics of a conventional theatre system. It probably consists of two heavy-duty 18 in. woofers mounted one above the other in a short folded horn. Above this is mounted the tweeter—a multi-cellular exponential horn excited by one or two driving units, mounted at the rear end, or throat. The woofer usually handles all the power below some frequency between 300 and 500 cycles per second. The tweeter handles all the power above this cross-over frequency.

This division of the total frequency range into two parts (in some of the older systems the audio spectrum was divided into three parts) is made for several reasons. First, it is extremely difficult to construct a speaker which will handle and deliver a full and undistorted bass output down to 30 c/sec. and also respond to those delicate overtones of a violin or harp which may go up to 15,000 c/sec. The problem of covering the entire audio range is very much simplified if two speakers can be employed, one handling all the rugged low frequencies, and the other the delicate high frequencies.

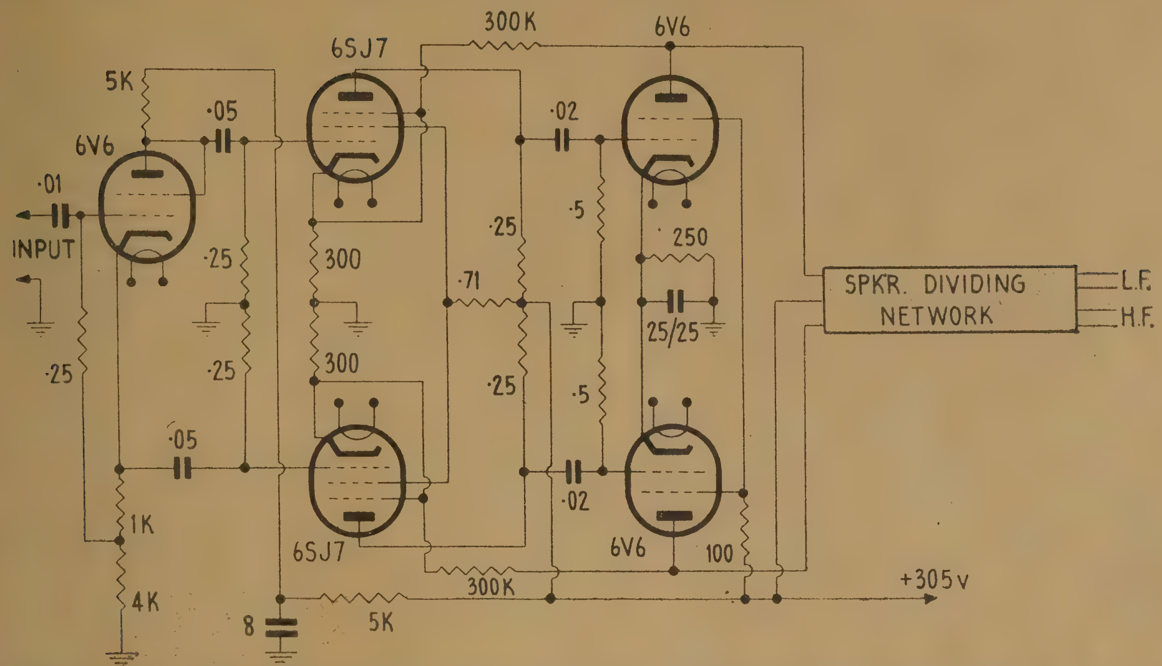
Secondly, when a loud-speaker handling a high note is also called upon to reproduce simultaneously a low note, we experience a very disturbing type of distortion due to what is known as the Doppler effect. What happens is that the high note is frequency modulated by the low one, and acquires that rasping quality which is so well known, and in some cases despaired of by those who insist on high quality.

By H. A. WHALE, M.Sc., Grad. I.E.E., Radio and Electrical Services Ltd., Auckland.

There are other bad effects which arise when the speaker is overloaded by a bass note, but we will not consider them here, since a low frequency speaker should be chosen which is capable of handling whatever is put into it.

Perhaps we can achieve the same quality in a speaker system on a smaller scale. We must first decide what is available in the way of speakers. We eventually decide on a 12 in. one for a woofer, and a 6 in. speaker for a tweeter. In order to achieve a relatively flat frequency response from the finished combination, it is necessary to use good speakers, preferably the new high-efficiency types. Having taken frequency response and impedance measurements on both speakers, the next step is to choose a cross-over frequency. This should be as low as possible, consistent with the power-handling capabilities of the high-frequency unit. In this respect is must be remembered that, if a 15-watt amplifier is being used, even the tweeter will have to handle the full 15 watts for short periods. The relative frequency of such an occurrence will depend on the cross-over frequency. For the two speakers mentioned, it is found that a cross-over at 1500 c/sec. is most suitable.

The speaker cannot be used yet; it is necessary to design suitable baffles for them. From the impedance measurements, the low-frequency speaker has been found to have a very pronounced resonance between 50 and 100 c/sec. This is responsible for the boominess usually experienced. It is possible to remove this resonance entirely by the use of a properly-designed acoustic baffle. In this case, it is decided that the most economical, as far as space and expense are concerned, is a bass reflex type. This baffle must be so designed that it entirely removes the natural bass resonance of the speaker; so that it is acoustically balanced in order not to distort the radiation field of the speaker, and is distributing power uniformly; so that no standing waves are set up in the resonance chamber at the higher frequencies, giving



Circuit for a high quality amplifier suitable for feeding the dividing networks and speaker system described in the text.

the well-known "tubbiness" that has come to be associated with baffles of this type. This latter effect can easily be eliminated by careful shaping of the box and the judicious use of damping material. Too much damping will entirely destroy the bass resonance removing properties of the box.

The orthodox type of bass reflex baffle has a port near the speaker opening. Much better results can be achieved by dividing this into two ports and placing one each side of the loud-speaker. In this way it is possible to construct a woofer with a bass response that is flat (1 db.) down to 30 c/sec., and will still handle 15 watts of audio at 20 c/sec. It has lately become the fashion to build and swear by what is called an "infinite" baffle, i.e., a totally enclosed box surrounding the speaker (not to be confused with the so-called infinite baffle which is really a crude form of bass reflex baffle). This type, sometimes called a Helmholtz resonator, is quite inferior to the true bass reflex type when it comes to radiation at frequencies lower than the natural resonance frequency, which is usually about 70 c/sec.

High frequency cone speakers suffer from two common faults. These are first, their low efficiency, due to the weight of the cone, and secondly, their very bad directional properties. Both defects may be remedied by mounting the speaker in a small horn, either exponential or hyperbolic. The low frequency cut-off of the horn must be sufficiently far below the cross-over frequency so that no distortion occurs due to residual power fed into the tweeter below the cross-over frequency. In order that a good, level frequency response will be obtained from the tweeter, it is necessary that radiation from the back of the cone be suppressed. This is achieved by adding considerable acoustical damping to the cabinet housing the tweeter.

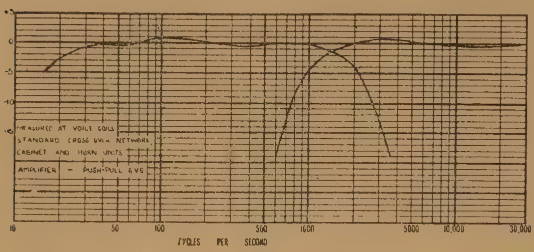
Having mounted the speakers in suitable baffles and having made sure that the response of each is flat in the range it has to cover, it only remains to excite them with their appropriate ranges of frequency. For this we employ a dividing network. This is merely a filter which presents the right load to the output tubes, and supplies the woofer with low frequencies and the tweeter with the high frequencies. Beyond the cross-over frequency, the desired range should be attenuated as sharply as possible. The sharper the attenuation, the more complicated, and incidentally, the more costly, is the filter. It has been found that for the system used here, an attenuation of 10 db. per octave is both necessary and sufficient.

In theatre installations it is common practice to employ a high-fidelity output transformer (an extremely expensive item) to a 500-ohm line. The filter is then placed in this line, at 500 ohms impedance, or at voice-coil impedance, following a further high-fidelity transformer from line to voice-coil. A considerable saving in expense can be realized by placing the filter directly in the plate circuit of the output stage, in which case only relatively low-priced output transformers are required. It has been further shown that by careful design of components, it is possible to reduce the price of the filter to very little more than that of the two output transformers required. The final adjustment of the system is to phase the two speakers. This consists in adjusting the relative motions of the cones so that their outputs add at the cross-over frequency. Since the filter employed gives exactly 180 degrees phase difference between the two speakers, it is possible to get exact phasing. This is important, because in some speaker dividing networks the phase-shift is not 180 degrees, and exact phasing is not possible.

It is then advisable to make a frequency response test of the whole system, first with dummy loads instead of the speakers, and then using the actual speakers. For the system here described, these measurements gave results fully justifying the trouble

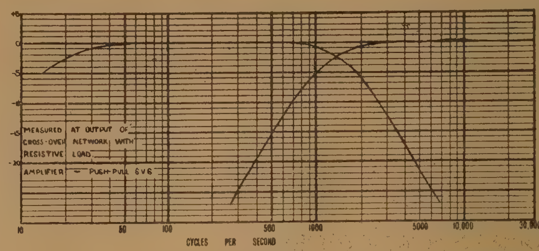
taken to obtain them. A typical set of curves is given in the diagram. These curves are for the speaker system described above. The amplifier used for driving the speaker system is purposely built to introduce the slightly drooping characteristic below 50 c/sec.

The most immediately noticeable feature of the system is the wide frequency range. It will reproduce everything from the lowest bass notes of an organ to the delicate overtones of a piccolo. Moreover, the lack of inter-modulation distortion is particularly striking, and in the case of some works (for example the Chinese Dance from the Nutcracker Suite) the realism is quite startling. Much of this "presence," as it is called, is due to the fact that no longer does all the sound come out of a "hole in the cabinet." The extended source imparts a fullness and body to the reproduction of big works that is impossible to achieve from a single speaker.



Measured at Voice Coils Standard Crossover Network Cabinet and Horn Units. Amplifier—Push-pull 6V6.

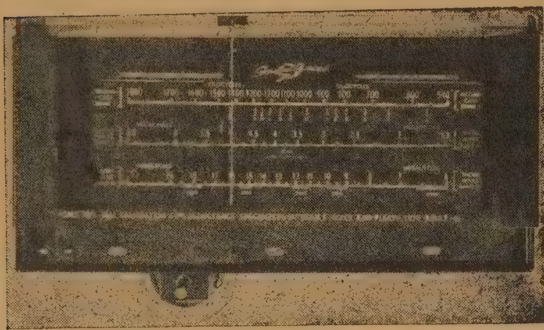
Finally, a word about what to put into your high-fidelity speaker system when you have acquired it. It is comparatively easy to build the voltage-amplifier stages of an audio amplifier, with perhaps means for equalizing records and broadcasts to give a flat response. Some care, however, is needed in the design of an output stage that is as nearly distortionless as possible. For the benefit of those who have had trouble building the latter, the accompanying circuit is given. It is that of the amplifier used in obtaining the above response curves. At least one stage of voltage amplification is necessary in front of this, and with the newer low-output, high-fidelity pick-ups, two stages.



Measured at output of Crossover Network with resistive load Amplifier—Push-pull 6V6.

Techniquality

NEW - DIAL [Movement] Type - D/2



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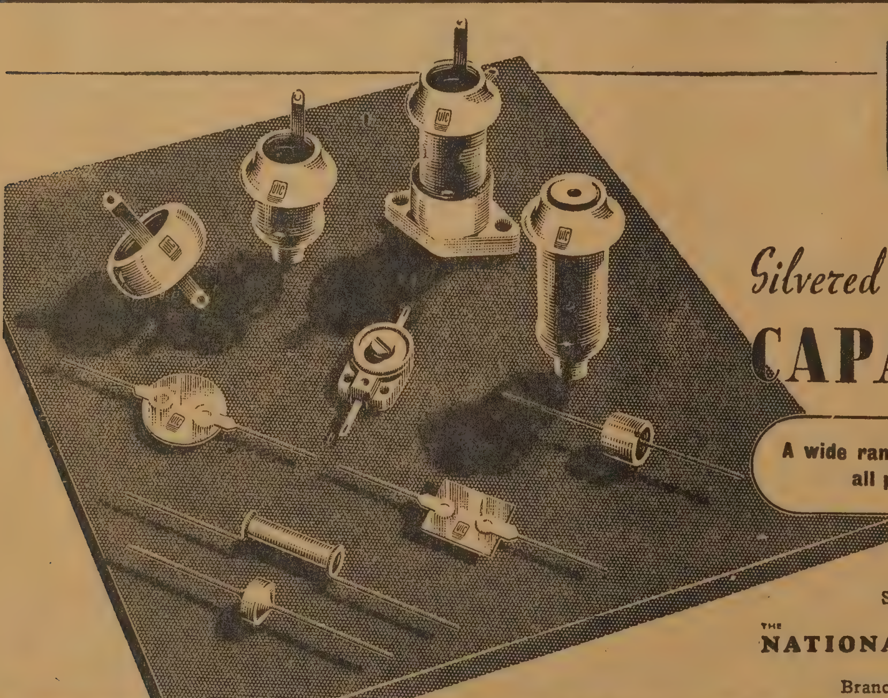

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RADIO RECEIVER POWER SUPPLIES

By the Engineering Department, Aerovox Corporation

PART III

To demonstrate practically the various conditions that may exist in a typical receiver power supply such as found in the average receiver, we have constructed a three-unit demonstration set. This demonstration set consists of a power supply unit containing two plate transformers, a universal filament transformer, and a number of sockets so that any of the current type rectifier tubes may be inserted. These units are not permanently wired together but may be connected by the means of plugs and jacks into any rectifier circuit desired. In addition, a Variac is in the primary of the plate supply transformers so that the input voltage to the plate supply transformer may be varied.

The second unit consists of four choke coils and three groups of condensers with a series resistance for varying the power factor of the condenser and a load resistance. With this arrangement, it is possible to set up any type of filter circuit with various values of inductance, capacity, and resistance. It is also possible to use two different types of choke coils, one having adequate core and copper, the other being of skimpy design.

The third unit consists of a D.C. voltmeter, 0 to 1,000 volts, a D.C. milliammeter, and a vacuum tube voltmeter for reading peak voltages to 1,000 volts and R.M.S. values of the A.C. component of the output voltage. In addition, a five inch cathode-ray oscilloscope is available so that the current or voltage wave shapes in any part of the circuit may be shown.

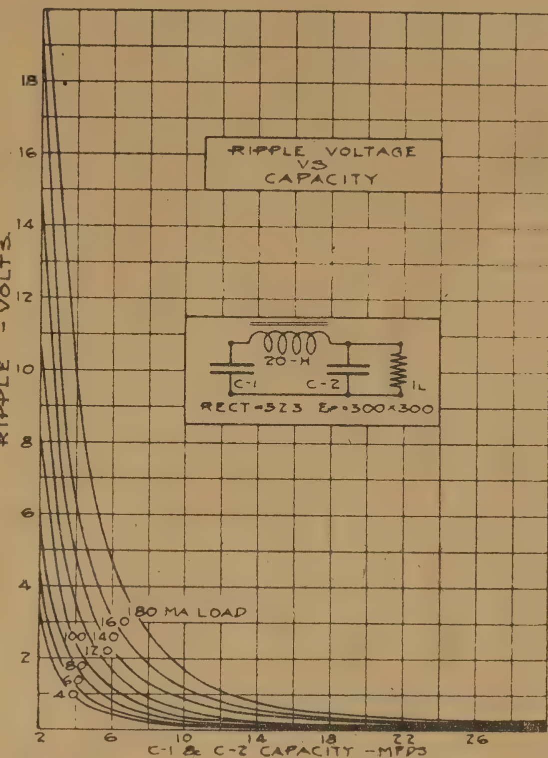


FIG 16

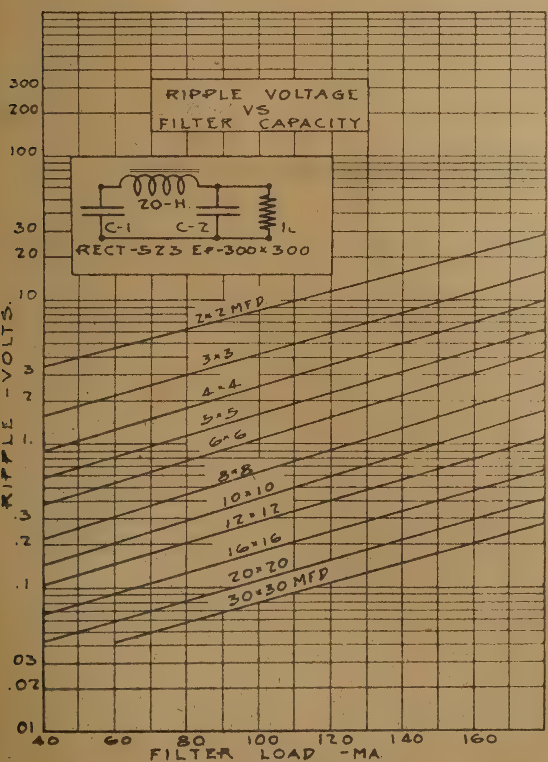


FIG. 15

To show the versatility of the set and to illustrate the various conditions that may arise in typical filter circuits and power supply circuits, a number of experiments were performed in the laboratory, the results of which are given in this paper. The following experiments were all performed on the full wave rectifier using a 5Z3 tube. The first experiment was performed to determine the variation in the output ripple voltage of a single section capacity input filter using one inductance, as the capacity of the condenser is varied. The apparatus was set up and the results are plotted in Fig. 15. As seen from these curves, the ripple voltage varies with the load current. The data obtained in this experiment were re-plotted as shown in Fig. 16 to show the effect of condenser size on the output ripple. It will be noted from the curves on Fig. 16, that the ripple voltage decreases rapidly with an increase in capacity and that the ripple voltage becomes practically constant and independent of the load current for capacities greater than 16 mfd. For low currents of the order of 40 milliamperes, a condenser of 8 mfd. is more than adequate. There is nothing to be gained by the use of larger condensers in the full wave rectifier circuit as the increase in output voltage, as shown by Fig. 25, is negligible for capacities greater

than 8 mfd., and the peak plate current increases rapidly with larger condensers.

The decrease in ripple voltage is inversely proportional to the product of the choke inductance and the output capacity of the filter. In addition, the ripple input to the filter decreases with an increased capacity. However, as noted above, there is very little improvement for condensers greater than 16 mfd., in fact, the increased plate current may be detrimental as it materially decreases the life of the rectifier tube. The output voltage is a function of the filter input condenser. The decrease in output voltage with increased load is caused by the voltage drop in the inductance and the decrease in the average voltage across the first condenser as the discharge rate of the condenser is increased by the larger load. This also causes an increased ripple voltage to appear at the filter input terminals. In addition, it is possible that the choke be operated at such values of load current so as to saturate the iron core and thus decrease the effective inductance of the choke. This decrease in inductance reduces the filter attenuation and thus allows a larger ripple voltage to appear in the output. Moreover, the magnetizing current of the choke coil increases very rapidly as the iron of the core becomes saturated thus producing an added A.C. voltage which appears in the output.

The maximum possible ripple voltage which can be tolerated is not easily determined as it depends on the type of receiver, the type of speaker, its low frequency response characteristics, the shape and size of the baffle in which the speaker is mounted, and the overall frequency characteristic of the audio channel. For high quality receivers and amplifiers, the hum output of the speaker should be about 40 to 60 db. below the average output. For less critical receivers, a hum level of about 30 db. can be tolerated. It should be noted that for receivers using a push-pull output stage, a larger percentage ripple voltage may be tolerated in the output stage, as the ripple components are cancelled in the plate transformer. Therefore if it is possible to take the plate supply for the push-pull output stage from a relatively simple filter, such as the speaker coil and one condenser, allowing the second filter section to be much smaller. In general, we may say that the ripple output voltage of a high quality rectifier unit should not exceed one-tenth of 1 per cent, or about three-tenths of a volt for a 300-volt unit. This may be obtained from a single section filter using a 10 x 10 mfd. condenser. For the average small type of set where a ripple voltage of one-half of 1 per cent. is allowable, a 6 x 6 or 8 x 8 mfd. condenser may be used. In the smallest size midgets, whose speakers are so small that the low frequency cut-off is well beyond 120 cycles a second, even smaller and cheaper filters may be used. For extremely good filtering, the filter sections may be cascaded, and where this is done the ripple voltage decreases inversely as the nth power of the number of filter sections. With such an arrangement, care must be taken that the filter sections do not act as the two quarter wave units in series, as the voltage rises rapidly at the centre point of the filter as this condition is approached. The graphs of Fig. 17 show what may be expected from a single and two-section filter.

Experiment No. 3 was performed to check the effect of two different types of choke coils on the output voltage and output ripple. Choke No. 1 is a poor-quality choke having a small core and a small number of turns. Choke No. 2 is a high-quality choke properly designed and constructed. As noted on the curves of Fig. 18, the D.C. output voltage is the same for both choke coils, as their resistance is essentially the same. The ripple voltage, however, is markedly different for the two chokes. At low-load currents, the ripple voltage is approximately the same, but as the current increases the poor-

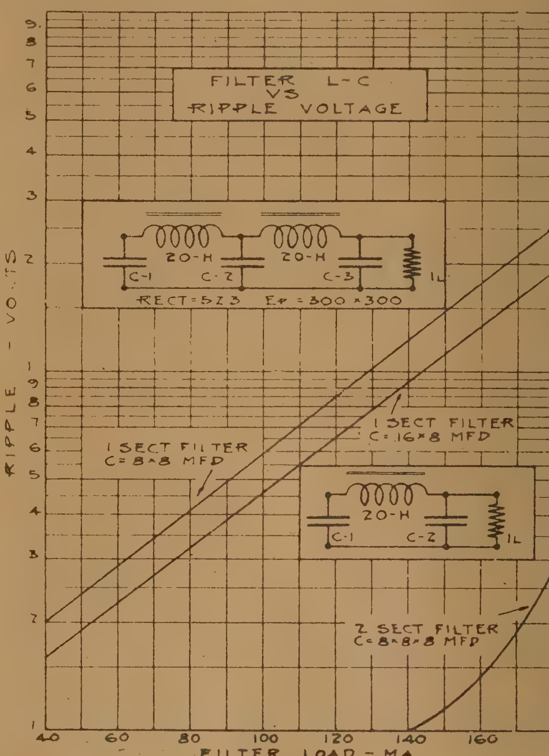


FIG-17

quality choke causes a larger ripple voltage to appear and at 170 milliamperes the ripple voltage of the poor-quality choke is 10 times as great as the ripple voltage for the good-quality choke. The output voltage is a function of the filter input condenser. The decrease in output voltage with increased load is caused by the drop in the A.C. voltage and the decrease in the average voltage across the filter condenser as the discharge rate of the condenser is increased by the larger load. This also causes an increased ripple voltage to appear at the filter input terminals as the attenuation of the filter is constant. In addition to this effect, it is possible that the inductance be operated at such values of load current so as to saturate the iron core and thus decrease the effective inductance of the choke. This decrease in inductance reduces the filter attenuation and thus allows a larger ripple voltage to appear in the output. Moreover, the magnetizing current of the choke coil increases very rapidly as the iron of the core becomes saturated, thus producing an A.C. voltage which appears in the output.

The curves of Fig. 19 were obtained in order to determine the efficiency of filtering a single section using (1) an 8 mfd. input condenser, a 20-henry choke, and a 16 mfd. output condenser, and (2)

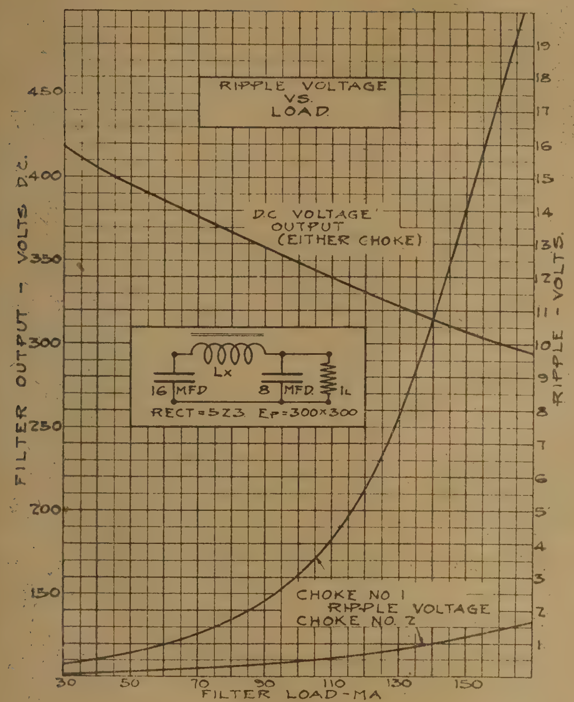


FIG. 18

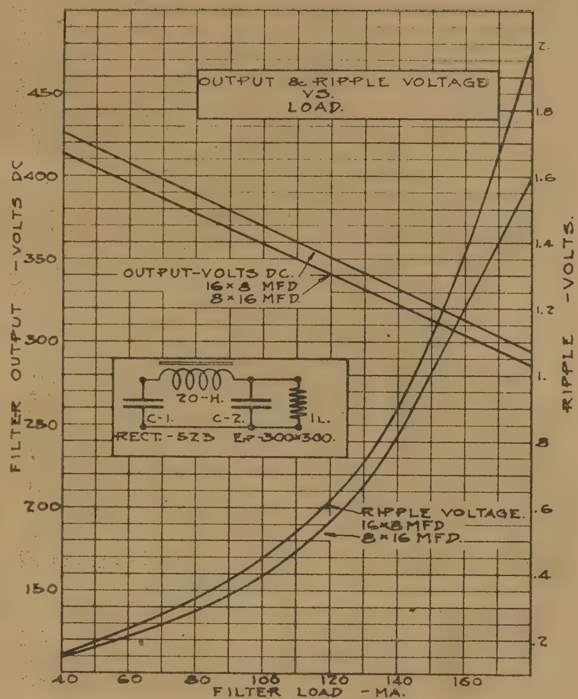


FIG. 19

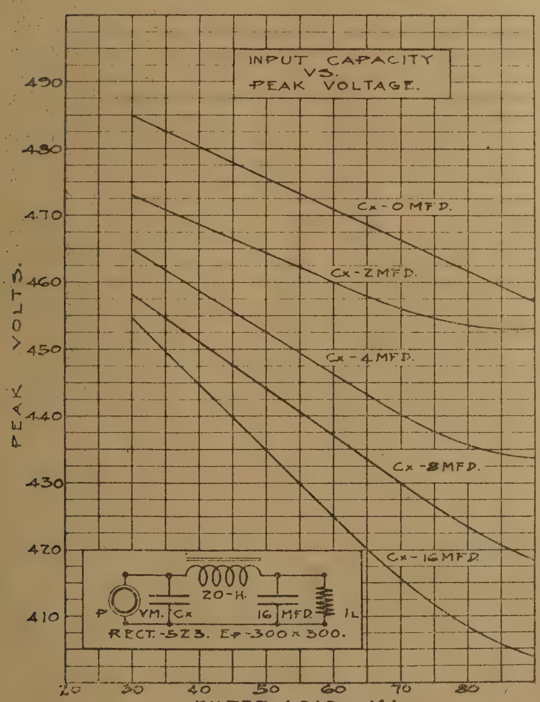


FIG. 20

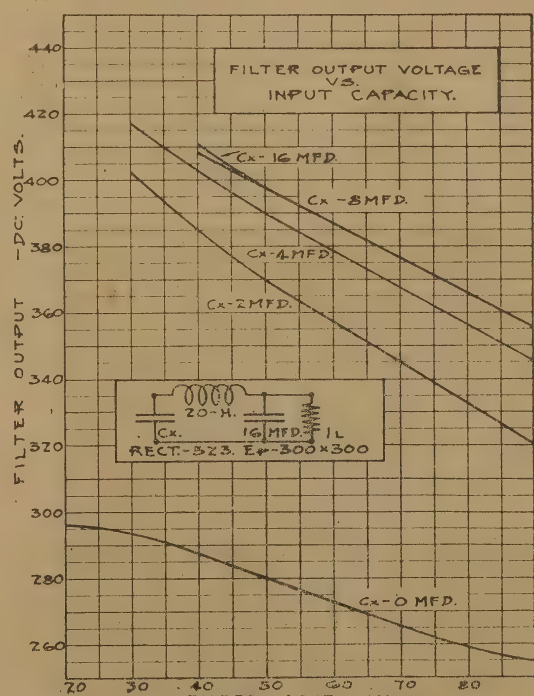


FIG. 21

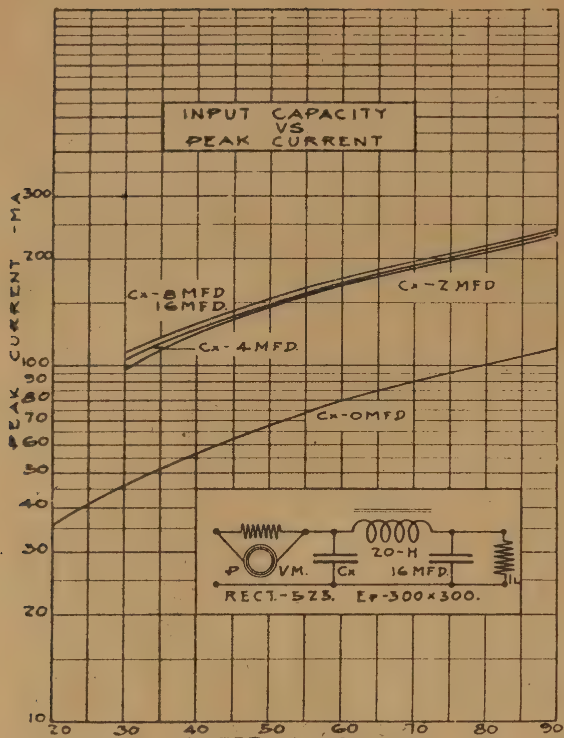


FIG. 22

a 16 mfd. input condenser, a 20-henry choke, and an 8 mfd. output condenser. It will be noted that the output voltage is slightly higher for the 16 x 8 combination than for the 8 x 16 combination. This is to be expected, as the average output voltage depends on the value of the input capacity. The ripple voltage, however, is higher for the 16 x 8 combination than it is for the 8 x 16 combination, although the ripple input to the filter is lower for the 16 x 8 combination than it is for the 8 x 16 combination, the ratio of the output condenser reactance to the load resistance for the 16 mfd. output condenser is much less than the corresponding ratio for the 8 mfd. output condenser.

To determine the magnitude of the peak voltage existing across the first condenser in a full wave filter circuit the data curves in Figs. 20 and 21 are given. It should be noted that the D.C. output voltage increases directly with the size of the input condenser; also that the peak voltage across the first condenser or the input to the filter decreases with an increase in the input condenser capacity. The peak voltage at the input to the filter is equal to the peak A.C. voltage applied to the tube less the tube drop, which is determined by the peak tube current. As the capacity of the input condenser increases, the peak plate current increases as shown in Fig. 22. It will be noted that the peak plate current may be as high as two and a half to three times the D.C. plate current, and the tube drop therefore is correspondingly increased, thereby lowering the peak voltage across the input through the filter. This peak voltage is maximum for a choke input filter and decreases rapidly with an increase in the capacity of the first condenser. For the particular circuit shown using a 5Z3 tube with a load of 80 milliamperes, using choke input with 300 volts R.M.S. applied to the plate, a peak input voltage of 462 volts was measured.

With an 8 mfd. input condenser using the same circuit and the same plate voltage, a peak voltage of 436 volts was obtained across the first condenser. The difference between the two values obtained, 26 volts, is due to the additional plate current in the tube which flows because of the input capacity of the filter. The peak plate current at 80 milliamperes for choke input circuit is about 100 milliamperes, while for an 8 mfd. input condenser the peak plate current is 218 milliamperes, an 118 per cent. increase. Although the use of an input condenser decreases the ripple voltage through the filter and increases the average D.C. output voltage, as was shown by Fig. 25, care must be used in the choice of condenser size, as the peak plate current may be of sufficient magnitude to materially decrease the life of the rectifier tube. With tubes having a low voltage drop such as the mercury vapour tubes (83) and tubes having very close spacing between the plate and the cathode, such as the 83-V and other tubes of similar construction, the peak plate currents may be even greater than the values obtained above, the limiting factor being the tube drop and the size of the input condenser. For mercury vapour tubes having a threshold voltage which must be exceeded before conduction of current begins, the use of large condensers in the input circuit is also the source of a

large amount of interference, requiring the shielding of the rectifier and the associated circuit and the use of radio frequency filters in the rectifier circuit to prevent the interference voltages from entering the plate circuit of the receiver.

There has been considerable discussion as to the effect of the higher equivalent series resistance of electrolytic condensers on filtering efficiency. This higher equivalent series resistance causes an increase in the power factor of the condenser. For some time it was generally understood that a condenser having a high power factor was a poor filter condenser. To determine the effect of power factor on the filtering efficiency of a condenser, series resistance was added to the filter condensers. Two curves were run, one with the series resistance added to make the power factor of the condensers 5 per cent., and the second one with sufficient resistance to increase the power factors of the condensers to 30 per cent. The load on the filter was then varied from 40 milliamperes to 180 milliamperes and the ripple voltage measured. It will be noted in the curves of Fig. 23 that up to loads of 140 milliamperes, the difference between the two circuits is indiscernible. Above 140 milliamperes, the maximum difference in the ripple output voltage is .2 of a volt. We can conclude, therefore, that, within the limits of measurement, the effect of power factor in filter condensers is negligible for power factors up to and including 30 per cent., and as the average power factor of a dry electrolytic condenser is approximately 5 to 10 per cent., no attention need be paid to condenser power factor as far as filtering efficiency is concerned. A high power factor, however, means that the power lost in the condenser is high, and for con-

(Continued on page 45.)

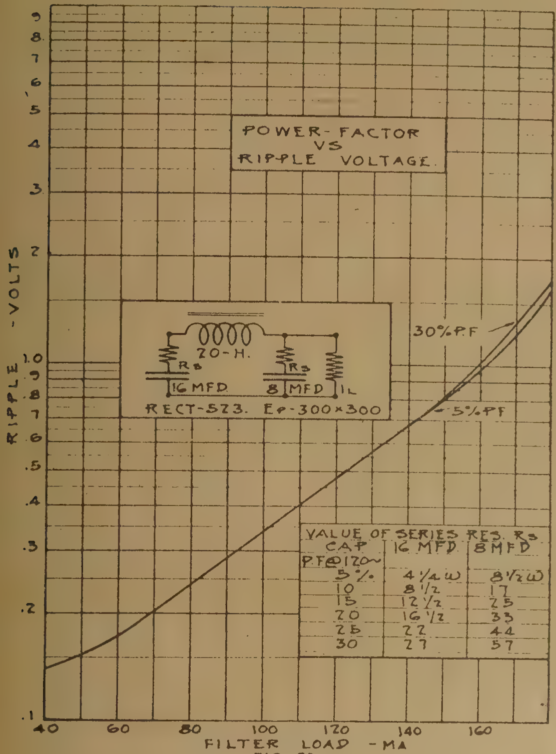


FIG. 23

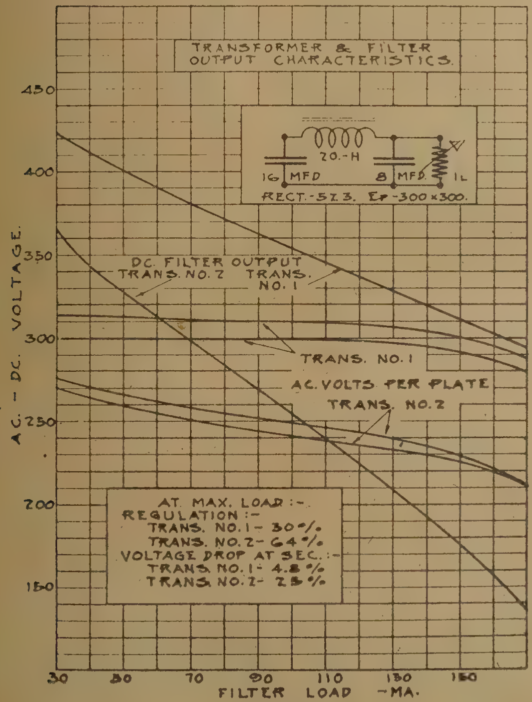


FIG. 24

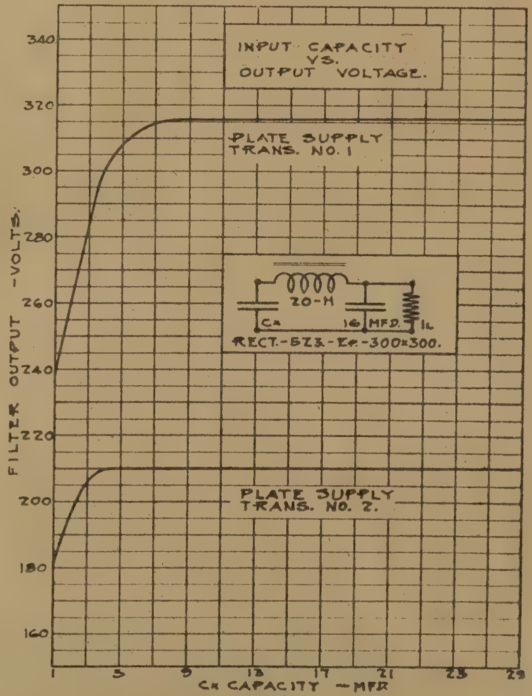


FIG. 25

PREDICTIONS FOR THE WORKING OF LONG-RANGE RADIO CIRCUITS ON AMATEUR FREQUENCIES

MAY, 1948

These frequencies are based on world charts of Maximum Usable Frequencies, prepared and issued by the Australian Radio Propagation Committee and supplied to "Radio and Electronics" by courtesy of this body and the New Zealand Department of Scientific and Industrial Research.

Contrary to normal commercial practice in the use of ionospheric predictions, the times given are derived from the Maximum Usable Frequencies, directly, and not from Optimum Working Frequencies, which are 15 per cent. lower.

The circuits are considered workable (a) if the band in question is below the M.U.F. at the time considered, and (b) if the said band is not lower than 65 per cent. of the M.U.F. If (b) is not satisfied, communication is unlikely, not because the frequency is not reflected by the ionosphere, but because the power available to amateurs is too low to overcome absorption in the ionosphere under these conditions.

Where the word "doubtful" appears in the tables, it indicates that between the times so labelled, the band is a little higher than the M.U.F. There is thus a possibility of effective communication on days when the actual M.U.F. is only slightly higher than that predicted.

All circuits have been assumed to start in Wellington. This creates the possibility of some slight error for other starting points, but this is of minor importance only, and does not justify the multiplication of the work involved.

ENGLAND

	N.Z.D.S. Time
Wellington to Liverpool:	
(a) North Route.	
14 mc./sec.	24 hrs.
30 mc./sec.	Nil
(b) South Route.	
14 mc./sec.	24 hrs.
30 mc./sec.	Nil

U.S.A.

Wellington to New York:	
14 mc./sec.	24 hrs.
30 mc./sec.	0600 — 0900
	0900 — 1130 (doubtful)
Wellington to New Orleans:	
14 mc./sec.	24 hrs.
30 mc./sec.	0600 — 1230
Wellington to Washington:	
14 mc./sec.	24 hrs.
30 mc./sec.	0600 — 1600
Wellington to San Diego:	
14 mc./sec.	24 hrs.
30 mc./sec.	0600 — 1530

CANAL ZONE AND SOUTH AMERICA

Wellington to Panama:	
14 mc./sec.	0330 — 0230
	0230 — 0330 (doubtful)
30 mc./sec.	0530 — 1030
	1030 — 1630 (doubtful)
Wellington to Pernamubco:	
14 mc./sec.	0400 — 0200
	0200 — 0400 (doubtful)
30 mc./sec.	0700 — 0830
Wellington to Buenos Aires:	
14 mc./sec.	0400 — 0230
	0230 — 0400 (doubtful)
30 mc./sec.	0730 — 0800

AFRICA

Wellington to Dakar:	
South Route.	
14 mc./sec.	0430 — 0330
	0330 — 0430 (doubtful)
30 mc./sec.	0730 — 1430
North Route.	
14 mc./sec.	24 hrs.
30 mc./sec.	0700 — 0930
Wellington to Cape Town:	
14 mc./sec.	0630 — 0500
	0500 — 0630 (doubtful)
30 mc./sec.	1600 — 1800
Wellington to Aden:	
14 mc./sec.	24 hrs.
30 mc./sec.	1300 — 2000

INDIA

Wellington to Karachi:	
14 mc./sec.	0700 — 0430
30 mc./sec.	1230 — 2000
Wellington to Colombo:	
14 mc./sec.	0700 — 0500
30 mc./sec.	1100 — 2000
Wellington to Calcutta:	
14 mc./sec.	0700 — 0400
30 mc./sec.	1100 — 1900

ASIA

Wellington to Hong Kong:	
14 mc./sec.	0600 — 0400
30 mc./sec.	0900 — 1900
Wellington to Singapore:	
14 mc./sec.	0700 — 0430
30 mc./sec.	1100 — 1930

The PHILIPS Experimenter

Inserted by Philips Electrical Industries of New Zealand.

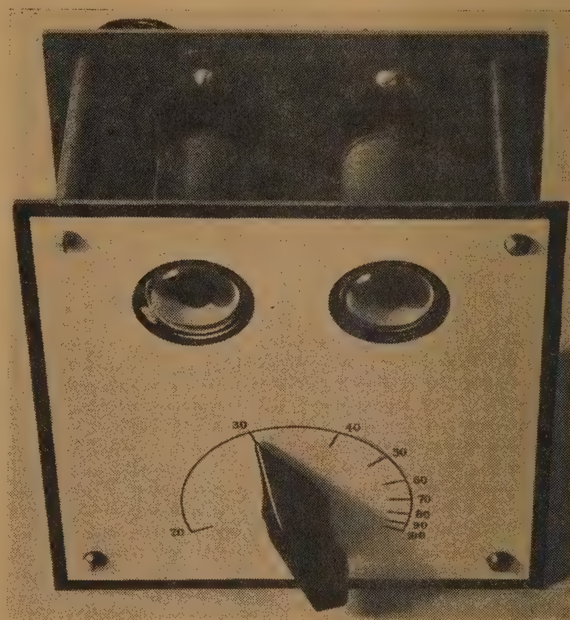
No. 7: AN INEXPENSIVE MODULATION PERCENTAGE METER.

While for many purposes an over-modulation meter or indicator seems satisfactory and sufficient, it is often of great convenience to be able to make direct measurements of modulation percentage. This has been realized by broadcast stations for quite some time, for a feature of technical periodicals which come from America has been the regular advertisement of devices which give constant readings of percentage of modulation, actually measured on the carrier, and not simply reading from the audio input to the transmitter. In the latter phrase is to be found a wealth of meaning, for, although so-called "volume indicators" are standard equipment in broadcast studios and in some of the better amateur stations, these give an indication of modulation percentage in a very indirect way; in fact, if the carrier should fail altogether at a time when the station is not being monitored "off the air," the volume indicator will give no indication at all of the occurrence. A modulation monitor, on the other hand, will tell the operator whether the carrier has failed, completely or partially, or if the modulators or, indeed, any section of the modulation equipment is not up to scratch. At the same time, the monitor can be used as a volume indicator, and can be set to show when any predetermined modulation level has been reached, giving a positive indication at all times.

Most commercial types of modulation meter are both complicated and costly, since they are designed to broadcast quality requirements and use vacuum-tube voltmeters for indicators. In general, their principle is as follows. A pick-up loop collects some of the transmitter output, which is rectified. A V.T.V.M. measures the rectified D.C. output voltage and serves as an indicator of carrier level, the procedure normally being to set the meter to a fixed reference point by means of a control which varies the carrier voltage fed into a further rectifier, which in turn has its D.C. output measured by a second V.T.V.M. Since the first meter has been used to set the carrier to a predetermined level, the meter which measures the rectified audio voltage can be calibrated in terms of percentage modulation. This is exactly the principle used in the meter described here. The important practical difference is that, in our case, the vacuum tube voltmeters are replaced by magic-eye tuning indicators. These enable the complete meter to be built for little more than the cost of three valves and a dozen or so resistors. Power requirements are very light, and can easily be supplied by any chassis on which the meter may be mounted. A low-impedance link can be used between the output and the input of the meter, which can then be placed on the operating desk, and powered from the receiver, if desired. Alternatively, where it is to be used with a small transmitter which is itself mounted on the operating table, room can usually be found to install it in the front of one of the panels, in which case it can derive its power from the chassis on which it is mounted.

TUBE LINE-UP AND CIRCUIT DETAILS

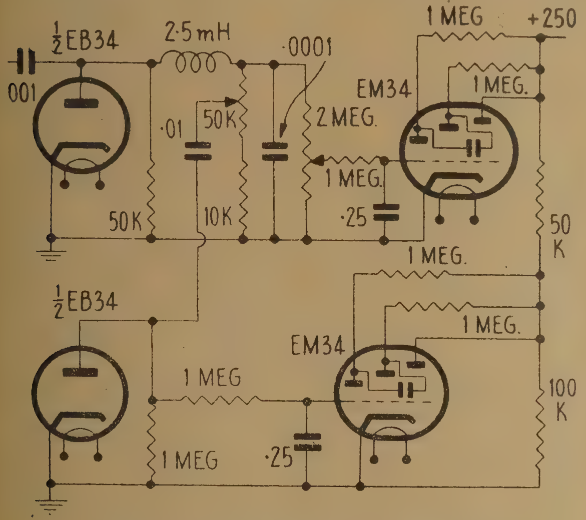
The rectifiers each use half of a Philips EB34, which is a double diode with separate cathodes. The dual-sensitivity EM34's are used for the voltmeter tubes. These have the advantage that the sensitive shadows can be used, allowing quite a small input voltage to operate the meter. R.F. input is fed to the top diode in the circuit diagram through



Showing the modulation meter built on a small sub-chassis. The front panel can be part of one of the main transmitter panels, or if desired the whole may be mounted in a small box.

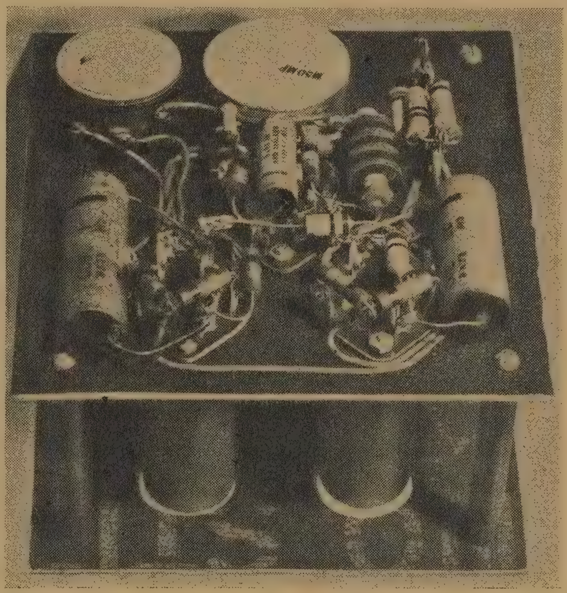
the 0.001 mfd. blocking condenser. Immediately following the tube is a 50k. load resistor, across which are developed a D.C. voltage proportional to the carrier amplitude and also the audio modulation. The 2.5 mH. choke and 0.0001 mfd. bypass condenser serve to filter out the R.F., and across the latter are connected two resistive shunts. The second of these on the diagram is a 2 meg. potentiometer, which is used when the meter is being set up to adjust the closure of the top EM34, which is the one which indicates that standard carrier level is being put out by the transmitter. The 1 meg. and 0.25 mfd. filter in the grid circuit of the eye tube is to filter out the modulation, since this indicator must not be affected by the presence or absence of modulation. The other shunt arm across the load resistor of the top EB34 consists of a 50k. pot. in series with a 10k. fixed resistor. This potentiometer is the one

which is finally calibrated in modulation percentage, and whose shaft therefore comes out to the front panel. From its moving arm, audio voltage is picked off and fed through a 0.01 mfd. blocking condenser to the second half of the EB34, which also acts as a shunt-connected peak-reading rectifier. The output of this rectifier is required to be a D.C. voltage, proportional to the audio voltage appearing across the load resistor of the R.F. rectifier, and therefore proportional to the degree of modulation of the carrier. To avoid flickering of the second eye tube, due to rectified audio components, a C.R. filter is placed in its grid circuit also. It will be noted that the eye acting as the carrier indicator has the full 250v. applied to its target, but that approximately two-thirds of the total is applied to the target of the other one. This is in order to increase its sensitivity compared with the carrier indicator, and so to enable it to read low percentages of modulation more easily.



HOW THE CIRCUIT WORKS

The above description shows what the component parts do in the circuit, but does not indicate how the instrument can enable modulation percentages to be measured. This depends on the characteristics of the peak-rectifying action of the diodes and upon the known relationships between the carrier and modulation components of a modulated wave. In the first place, to a fairly close approximation, the diode circuit used produces across its load resistor a D.C. voltage equal to the peak value of an unmodulated carried that is fed into it. If the carrier is now modulated, but not by more than 100 per cent. in either the positive or negative direction, the value of the D.C. voltage developed does not change. If over-modulation occurs, then the voltage referred to alters, and this fact is made use of in the ordinary types of carrier-shift over-modulation indicator. However, the property that is of use to us here is that the D.C. output of the first diode is constant, for a given carrier input, irrespective of the depth of modulation, as long as over-modulation is avoided. Suppose, for the sake of argument, that we are feeding into the top diode an unmodulated carrier voltage of 20v. peak. Then (assuming 100 per cent. rectification efficiency in the diode), there will be 20v. D.C. across the 2 meg. input pot. to the top EM34. It is therefore possible to find a setting of this pot. at which the eye just closes. When the potentiometer has been set in this way, we are assured that whenever the top eye-tube's shadow is just closed, we have 20v. peak carrier voltage applied to the input. Now, if a 100 per cent. modulated wave is rectified, there is produced across the rectifier load not only the D.C. voltage already referred to, but also an audio voltage EQUAL IN PEAK AMPLITUDE TO THE PEAK CARRIER VOLTAGE. If now we cause this audio voltage to operate a second magic eye tube just to full closure, any smaller closure of the second eye indicates that the modulation of the carrier is something less than 100 per cent. If the scheme were feasible, we could calibrate the screen of this eye to read percentages of modulation. That we do not actually do this is merely because of the small size of the screen and the impossibility of making calibration marks on it. Instead,



Rear view of the unit. The EB34 is mounted between and below the two eye-tubes. The left-hand one is the carrier-level indicator.

therefore, we vary the audio input to the eye circuit, with the 50k. pot., and calibrate this in modulation percentage. Now, we take a measurement by adjusting the potentiometer until the lower eye is just closed, and then read off the answer from the scale marked round the pointer. The necessity for the second rectifier becomes obvious when it is remembered that a magic eye tube must be operated by D.C. voltages on its grid if the shadow is to be sharply defined.

When the input has been set to the reference level by means of varying the coupling between the pick-up loop and the transmitter, 100 per cent. modulation will obviously be indicated with the moving arm of the calibrated potentiometer at the low potential end. Also, the ratio between the values of the pot. and the fixed resistance in series with it determines the minimum percentage of modulation that can be

measured. In our case, the minimum was slightly under 20 per cent., which is quite low enough for all practical purposes. Although the voltage developed across the 50k. pot. is linear with respect to modulation percentage, a potentiometer with a linear law does not give a linear scale. This is because the pot. works in an inverse manner. That is, the more resistance in circuit, the smaller the percentage modulation. It might be possible to realize a more linear scale by using a carbon pot., which normally has a semi-logarithmic law, but in the OPPOSITE direction to usual. In this case the scale will read from right to left, but there is nothing that can be done about this, as, if the pot. is connected in the usual way, the cramping of the scale would be much worse than that shown in the illustration.

CALIBRATION

A device like the one we are describing is of little use to amateur constructors if it cannot be calibrated without the use of special equipment, and one of the virtues of the present design is that it can be calibrated with the aid of only a D.C. voltmeter and some dry batteries. The circuit values have been arranged on the assumption that 17½ volts peak carrier will be used as the reference level. This is very easily obtained, since there are several hundred volts of R.F. to be found in the tank circuit of even a low-powered job. However, since there will normally be some slight difference between the sensitivity of different EM34's, the calibration procedure outlined below has been designed to take care of this fact. Nevertheless, batteries to the extent of about 20 volts will be needed for the calibration. An important point to note is that in all the measurements of D.C. voltage made during calibration, the voltmeter should never be connected to the moving arm of the 50k. pot. The process is as follows:—

(1) Connect 17.5v. of battery across the 50k. fixed load resistor of the top diode, with the negative terminal to the diode plate and the positive to chassis.

(2) Connect the voltmeter directly across the battery.

(3) Short-circuit the 0.01 mfd. condenser between the moving arm of the 50k. pot. and the plate of the lower diode.

(4) Turn the potentiometer fully in the direction that gives minimum deflection on the lower eye. The top or carrier indicator eye is completely disregarded at this stage.

(5) Note whether the lower eye is still fully closed or not. If it is, the 17.5v. should be reduced in steps of 1½v. until the eye is just not fully closed. If with the original 17½v. it is quite wide open, the voltage should be increased until it is just closed. When the closest possible adjustment has been made by altering the D.C. input voltage in 1½v. steps, either way, as necessary, a final adjustment is made by moving the potentiometer arm to give exact closure of the eye. THE POSITION OF THE POINTER IS NOW MARKED AND LABELLED 100 PER CENT.

(6) Measure the voltage at the plate of the upper diode, i.e., the battery voltage in use. Call this V.

(7) Alter the voltage to nine-tenths of V. Then readjust the pointer of the 50k. pot. until the eye just closes again. Mark the point at which the new setting is found 90 per cent. Change the input voltage again, this time to eight-tenths of V., adjust the pointer again, and call the new setting 80 per cent. Continue the process for each 10 per cent. point lower until 20 per cent. has been marked. The dial is now completely calibrated.

(8) Reset the input voltage to the value V. Now set the 2 meg. pot. in the grid circuit of the upper EM34 until it just closes. This eye is now set so as to indicate a carrier level of V. volts peak. Thus, when an R.F. signal is fed into the meter and its amplitude is adjusted so that the upper eye closes, the modulation percentage can be read from the pointer in the manner described above.

In order to be able to set the D.C. input voltage to the exact values required in calibrating, it is best to connect a potentiometer of about 2000 ohms across the battery and the moving arm to the top of the diode load resistor. The voltmeter, of course, should be connected between the moving arm of this auxiliary pot. and earth.

ADJUSTMENT OF INPUT VOLTAGE

In the circuit diagram no specific input arrangements have been shown, purposely, since there are a number of arrangements that can be used according to circumstances. If the unit is situated on the same chassis as the modulated amplifier stage, a short piece of wire attached to the 0.001 mfd. input condenser as an aerial will probably be sufficient, and the input voltage can be regulated by adjusting the placing or length, or both, of the wire.

It cannot be too strongly emphasized that the closure of the carrier level indicator must on no account be adjusted with the 2 meg. pot. after the calibration has been made, and that this adjustment should only be made by means of the input coupling, whatever scheme is used.

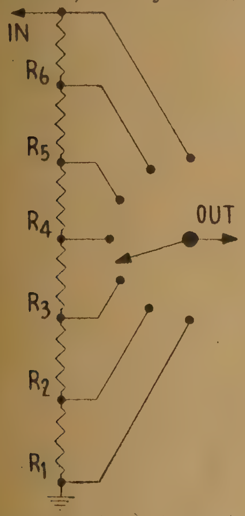
The other scheme, already referred to, is to use a low-impedance link attached to the input diode and terminated in a one or two-turn loop whose coupling to the mod. amp. tank circuit can be varied until the carrier eye is closed.

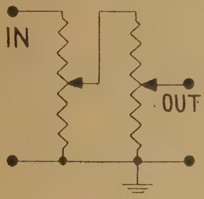
If it is desired to have the unit on the operating desk, the above system can still be used; in this case perhaps the best arrangement is to connect a tuned circuit between the input condenser and earth, and to couple the link to it. This enables the exact coupling between the meter and the transmitter to be adjusted at the operating position, but care should be taken to see that the circuit is always properly tuned to resonance, otherwise the meter will not read correctly, even if correctly calibrated.

Next month's Experimenter will contain some tips on getting the most out of the EF50 as a low-powered master oscillator, either self-excited or crystal controlled.

Tables for the Computation of Decibel Attenuators

The decibel attenuator is an extremely useful piece of equipment for any laboratory to possess. It can be used in conjunction with oscillators and output measuring devices for the measurement of the gain of amplifiers, for taking frequency response curves directly in db., and for a large number of other purposes. The instrument in its simplest form is simply a voltage divider, constructed round an eleven-point wafer switch, in which each tap gives an attenuation of a known number of db. For instance, a very useful type would have ten points,





Left: Fig. 1, showing a five-step attenuator. Note that the points giving zero and infinite attenuation are not counted as steps for the purpose of calculation. Thus a five-step attenuator has six resistors, and a 10-step attenuator, 11 resistors.

Above: Fig. 2.

each giving 3 db. more than the last. The calculation of the resistor values for making such attenuators is simple, but tedious, so we have prepared a number of tables which enable the values for certain useful cases to be read off at sight. A feature of the simple voltage-divider type of attenuator is that it has a constant input impedance, equal to the sum of all the resistors in the chain, but that the output impedance varies over fairly wide limits. In all cases for which tables are given, it is the input impedance, or total resistance that is stated at the top of the column. If it is desired to construct an attenuator having a different input impedance, it is only necessary to multiply all values in the table by a factor which, when multiplied by the original impedance, gives the desired new one. For example, if the table is given for an attenuator of 1,000 ohms input impedance, and it is desired to make from these figures a table for an attenuator of 1 megohm, it is necessary only to multiply all figures by 1,000.

There are a number of types of decibel attenuator which can be useful, but all of them can be made more useful still by combining them with a continuously variable attenuator, giving a maximum attenuation at least equal to the number of db. between points on the stepped control. For instance, if we have an attenuator giving 30 db. in steps of 3 db., we would need a continuous control covering only 3 db. This would give us continuous control over the whole 30 db. range.

For many purposes, readings are not needed, nor can they be taken accurately, to less than 1 db. In

this case, a continuous control is unnecessary, and steps of 1 db. can be used. A difficulty here is that an ordinary eleven-point switch will only allow an attenuator of 10 db., and the maximum attenuation needed may be more than this. Simple voltage-divider attenuators are not easy to combine in cascade without introducing errors due to the shunting of one by the other, but as long as care is taken to see that the input impedance of the second one is much higher than that of the first, the inaccuracy will be quite small. This is illustrated in Fig. 2.

In making attenuators of this sort, it must be remembered that there is a small but inevitable capacity between switch contacts. These capacities act to increase the amount of attenuation at high frequencies and are more effective in so doing, the higher the input impedance of the device, and, in a given attenuator, there is more unwanted attenuation the lower the attenuation used. Thus, even if the resistors are very accurately chosen at low audio frequencies, the attenuator may lose its accuracy at the highest audio frequencies unless a low-capacity switch is employed. For all audio frequency work, wafer switches are quite satisfactory, even at quite high impedances.

Another precaution which must be observed in the use of this type of attenuator is that its input impedance must be many times higher than the output impedance of whatever is used to feed the attenuator. If this is not so, the connection of the attenuator to the equipment will reduce the output voltage, and true measurements will not be obtained. For example, supposing the attenuator were to be used between a crystal gramophone pick-up and an amplifier in order to measure the frequency response of the pick-up. The latter requires, say, a load resistor of 1 meg. for proper operation. If an attenuator of ½ meg. input impedance were connected to the pick-up, the resultant load would be only ½ meg., and the response curve would represent the performance of the pick-up with a ½ meg. load, and not a 1 meg. load. About the only cure in this case would be to terminate the pick-up in the correct 1 meg. load, feed the output to an amplifier with an output impedance much lower than the input impedance of the attenuator, and connect the latter after the amplifier.

Values for Five-step Attenuator, 10 db. per Step, Input Impedance, 1000 ohms

$R_6 = 683.8$ ohms
$R_5 = 216.2$,,
$R_4 = 68.38$,,
$R_3 = 21.62$,,
$R_2 = 6.838$,,
$R_1 = 3.162$,,

"RADIO AND ELECTRONICS"

Back and current numbers of "Radio and Electronics" may be obtained from—

Te Aro Book Depot, Courtenay Place, Wellington.
S.O.S. Radio Service Ltd., Queen St., Auckland.
Tricity House, 209 Manchester St., Christchurch.
Ken's Newsagency, 133–135 Stuart St., Dunedin.

Values for Ten-step Attenuator, 3 db. per Step, Input Impedance, 1000 ohms

$R_{11} = 292.1$ ohms
$R_{10} = 206.7$,,
$R_9 = 146.4$,,
$R_8 = 103.6$,,
$R_7 = 73.4$,,
$R_6 = 51.9$,,
$R_5 = 36.78$,,
$R_4 = 25.91$,,
$R_3 = 18.54$,,
$R_2 = 13.05$,,
$R_1 = 31.62$,,

Values for Ten-step Attenuator, 1 db. per Step, Input Impedance, 1000 ohms

$R_{11} = 108.7$ ohms
$R_{10} = 97.0$,,
$R_9 = 86.4$,,
$R_8 = 76.9$,,
$R_7 = 68.7$,,
$R_6 = 61.1$,,
$R_5 = 54.5$,,
$R_4 = 48.6$,,
$R_3 = 43.3$,,
$R_2 = 38.6$,,
$R_1 = 316.2$,,

Values for Ten-step Attenuator, 2 db. per Step, Input Impedance, 1000 ohms

$R_{11} = 205.7$ ohms
$R_{10} = 163.3$,,
$R_9 = 129.8$,,
$R_8 = 103.1$,,
$R_7 = 81.9$,,
$R_6 = 65.0$,,
$R_5 = 51.7$,,
$R_4 = 40.8$,,
$R_3 = 32.8$,,
$R_2 = 25.9$,,
$R_1 = 100.0$,,

Values for Ten-step Attenuator, 4 db. per Step, Input Imepdance, 1000 ohms

$R_{11} = 369.0$ ohms
$R_{10} = 232.9$,,
$R_9 = 146.9$,,
$R_8 = 92.70$,,
$R_7 = 58.50$,,
$R_6 = 36.90$,,
$R_5 = 23.29$,,
$R_4 = 14.69$,,
$R_3 = 9.27$,,
$R_2 = 5.85$,,
$R_1 = 10.00$,,

TONE CONTROL SYSTEMS

by C. R. LESLIE

PART III (Conclusion)

Another method of tackling the problem and which may be found simpler to design and construct is to use the paraphase principle and embody high and low pass filters. The filters may be conveniently designed to effect a cross-over at some pre-determined frequency, such as 400 c/s. The high-pass filter may take the form shown in Fig. 14, where (A) is the filter and (B) the resultant response curve, and the low-pass filter and response curve as shown in Fig. 15 (A) and (B). To prevent loading effects

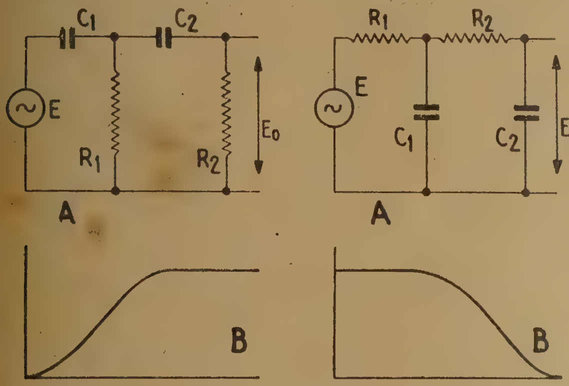


Fig. 15.

on the first section of each filter a corrective factor must be used for the components of the second section—if this factor is greater than 5 so that $C_2 = C_1 \div 5$ and $R_2 = R_1 \times 5$, the loading is negligible for practical purposes, so that for complete safety and convenience we can make this factor 10.

For the high pass filter of Fig. 14 (A) the output voltage E_0 can be calculated from the equation,

$$E_0 = E\frac{R}{R + 1/j\omega C} \times \frac{10R}{10R + 10/j\omega C} \quad . \quad . \quad . \quad 1$$

$$\text{or,} \qquad E_0 = E\left[\frac{j\omega CR}{1 + j\omega CR}\right]^2 \quad . \quad . \quad . \quad 2$$

$$= E\frac{(\omega CR)^2}{(1 + j\omega CR)^2} \quad . \quad . \quad . \quad 3$$

$$\therefore \ |E_0| = E\frac{(\omega CR)^2}{1 + (\omega CR)^2} \quad . \quad . \quad . \quad 4$$

From equation 4 it will be seen that the response will be 6 db. down when $\omega CR = 1$. By similar reasoning it will be found that for the low-pass filter the response will also be 6 db. down when $\omega CR = 1$. If these two circuits are connected to equal voltage sources in anti-phase their net output will be the vector sum of the two outputs, assuming that the two filters do not have any loading effect on each other. The complete circuit will then appear as in Fig. 16, where it will be seen that the tone control is effected by adjustment of the anode and cathode potentiometers of V_1. Since such a paraphase system requires an amplifier (V_2) it may be conveniently added by embodying V_1 and V_2 in a single envelope as a double triode.

The values of the components can be easily calculated as a design basis by assuming an arbitrary generator impedance of, say, 1,000 ohms, and a cross-over point at, say, 400 c/s., keeping to our previous factor of 10. Choose a suitable value for C_1 and C_3, say, 0.005 mfd., then C_2 and C_4 will be 0.0005 mfd. Then R_1 and R_3 will equal

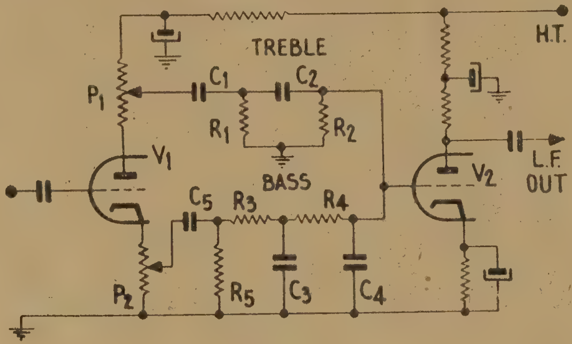


Fig. 16.

$$1/2\pi fC, \ = 1/2 \times 3.14 \times 400 \times 5 \times 10^{-9},$$

which is 79,640 ohms. The nearest standard value is 82,000 ohms, and therefore R_2 and R_4 will be 820,000 ohms each. For greater accuracy choose resistors

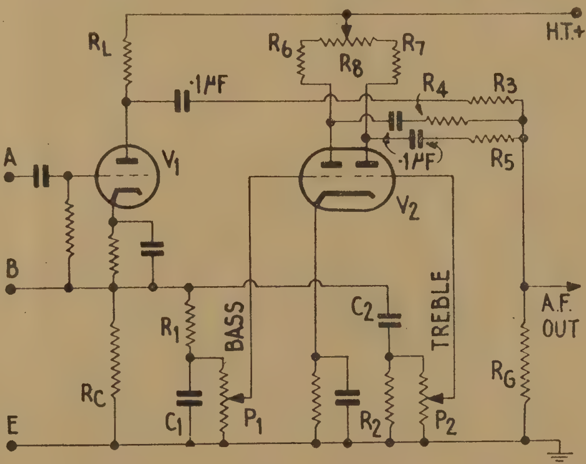


Fig. 17.

that are slightly less than these amounts and yet are reasonably proportional to each other. The potentiometers, P_1 and P_2, for anode load and cathode resistance will be 1,000 ohms each to represent the impedance of the generator. The decoupling con-

denser C_5 and resistor R_5 should have a high CR value which is not critical and may be made 1 mfd. and 1 meg. respectively. The anode circuits of V_1 and V_2 (which may be a 6SN7) should be thoroughly decoupled.

Another paraphase system, due to Patchett, is of considerable interest as it possesses some unusual features. It makes use of the basic circuits of Figs. 4 (A and B) and incorporates a separate output for the middle range of frequencies, with the result that we have bass and treble "boost" without variation of the middle audio range. The complete circuit is shown in Fig. 17, where it will be noticed that there are two possible inputs, between A and E and between A and B. If fed between A and E, then V_1 acts as a cathode follower since R_1, R_c, and the loading of the two tone control filters, R_1, P_1, C_1 and C_2, P_2, R_2, across the cathode resistance R_c does not produce any distortion in V_1 owing to its low output impedance, but the output from R_c to the filters is only 0.9 of the input voltage. If the input voltage is applied between A and B, V_1 acts as an amplifier, but some distortion is likely unless great care is taken in the selection of component values because of the omission of feedback from R_c.

The voltage across R_c is fed to the two tone control circuits and their outputs via the sliders of the potentiometers fed to the two grids of the double triode. We now have three outputs: from the anode of V_1 for uncontrolled signals, and from the anodes of V_2 for bass and treble "boosted" signals. It will be seen, therefore, that the control responses need not cross over at some fixed frequency as in the previous circuit, but can be made to operate at the limits of a pre-determined range of middle frequencies which remain unaffected by the controls. This permits of great elasticity of design to suit the particular conditions pertaining to the reproducing stage and acoustics of the room. To prevent interaction between these three outputs, stopper resistors R_3, R_4, R_5, are inserted after, and in series with, the coupling condensers of 0.1 mfd. each. The resistors may be of 100,000 ohms each, while the grid-leak R_g of the succeeding stage may be 1 megohm. The writer suggests that greater flexibility will be achieved if the anode loads of the double triode are split by a potentiometer R_8 as shown so as to vary the amplitude of the treble or bass output as an overriding adjustment.

CONCLUSION

Although these articles do not pretend to exhaust the possible varieties of tone compensation systems it is hoped that they will be of assistance to constructors by giving a reasonably wide range of lines that may be followed. After all is said and done, individual tastes do vary and a compensatory system that is suitable for one listener may be anathema to another. The foregoing ideas should be sufficient to cover the requirements for the majority, both from the point of view of simplicity, or otherwise, of design and construction and of aesthetic tastes; as it is a case of hitting on the right system to suit the individual, perhaps it is as well not to confuse the issue by offering too many items to select from.

QUESTIONS & ANSWERS

THE "RADIO AND ELECTRONICS" DA30 AMPLIFIER

C.H.H., Palmerston North, writes as follows:—

"I would be obliged if you would answer a few questions about the power pack of the DA30 amplifier.

"(1) What would be the result of substituting three 16 mfd. electrolytics for the 4 mfd. 1,000v. oil-filled condenser specified in the diagram?

"(2) When electrolytics are connected in series, as for C_2 and C_3, is there any choice between wet and dry types?

"(3) The agents for the DA30's have informed me that these valves are supplied in matched pairs. Can it be taken from this that C_4 and C_5 can be omitted?

"(4) I have arranged two groups of leads from the power supply to the amplifier. Should these be shielded, and would their length be of any consequence?

"(5) Would you please tell me the best type of loud-speaker to use with the amplifier?"

For the benefit of readers who may not be conversant with the amplifier under discussion, we would like to point out that it was described in the August, 1947, issue of this journal, under the title of "A Very High Quality 20-watt Amplifier." Now, taking C.H.H.'s questions in order:—

(1) Three electrolytics in series could be used as suggested, and would have no noticeable effect on the performance of either the power supply or the amplifier. In our article the single oil-filled condenser was specified on account of its superior ruggedness. In the position as the input condenser of a condenser-input type of filter it is called upon to withstand a high-voltage surge when the supply is first switched on unless either the filaments of the power valves are switched on first, or else they heat up sooner than the rectifier filaments. Oil-filled condensers are much better able to stand up to such a surge than are electrolytics, and can therefore be expected to give longer life. However, if three of them are connected in series, the combination will have a total working voltage of 1,350, which is about twice the surge voltage that can be expected in this circuit. The other disadvantage of the electrolytics in series is connected with the answer to question (2).

(2) It would be imperative to connect equalizing resistors across each condenser in the chain, as is specified in the caption to the power supply diagram for C_2 and C_3. However, it should be pointed out that these resistors are not to be considered as absolute protection against breakdown. The reason is to be found in the reason for having equalizing resistors at all. It is well known that electrolytic condensers have quite appreciable leakage which is a natural consequence of the manner in which they work, and is quite normal. However, it is not possible for all condensers of the same type to have exactly the same leakage. Thus, one may behave as though a resistor of 3 megohms is in parallel with an ideal, leakless condenser, while the leakage resistance of another of the same type may be as much as 10 megohms. Now, let us consider what happens when these two condensers are connected in series and placed across a source of high voltage. The total leakage resistance would be 13 megs., and so 10/3 of the total voltage would be found across the one which has 10 megs. leakage resistance. Thus, if the condensers were rated at 450v. working, and the total voltage across the pair is 800v. (well within their combined rating) the aforementioned condenser would have 10/13 of 800v. = 630v. across it. The best condenser of the pair would then break down very quickly, after which the whole 800v., or very near it, would be impressed upon the remaining one, which would proceed to break down even more smartly. But if a 1 meg. resistor had first been connected across each condenser, the leakage resistance of each would have been decreased to almost the value of the shunt resistors. There would still be some slight inequality between the voltages across the individual condensers, but this would now amount to only a few volts and each would be working within its rated voltage, as was originally intended. The main disadvantage of series electrolytics can now be readily appreciated. Unless each condenser in the chain remains good, and therefore its leakage does not become worse, all three will be destroyed when one of them does give out. In other words, the chances of breakdown in a series combination of three are three times as great as is the chance of a single electrolytic breaking down. This is not to say that using condensers in this way is bad practice, and should not be used; it simply gives a lead to a constructor or designer when he is estimating whether first cost is more or less important than providing the utmost in reliability. This in turn depends upon the use to which the equipment is to be put. In passing, it might be of interest to note that over the two years during which we have been constructing prototype equipments for description in these pages, we have used large numbers of dry electrolytic condensers, and the only failure we have had was when one was accidentally connected the wrong way round. Even then it lasted for about ten seconds before emitting smoke and dragging the voltage down! Which brings us to the real point of this question, namely, whether wet or dry electrolytics are best for connecting in series. The answer is definitely in favour of the dry variety. These have a much higher leakage resistance than the wet types, with the result that the equalizing resistors can be much higher in value than if "wets" were used. This in turn allows the input condenser to give much more efficient smoothing.

(3) If the DA30's are well matched, it is possible to use a common bias resistor, because they will have identical plate-currents and will therefore provide themselves with identical operating conditions. However, the provision of separate bias resistors is good practice, and allows for the case where one tube only has to be replaced, in which case the pair might be distinctly unbalanced unless such provision was made. If separate bias resistors are used, each must be bypassed in order to prevent degeneration. If a common bias resistor is used, this need not be bypassed, because the audio currents from the two tubes are equal in magnitude and exactly out of phase in the resistor, and so cancel out. There can then be no degeneration.

(4) There should be no necessity for the shielding of any of the power supply leads unless they are run close to the input tubes, which is bad practice, and should not be done in any case.

(5) It will be realized that we cannot recommend any specific make of loud-speaker, but we would like to emphasize that the best possible should be used with any high-quality amplifier. A permanent

magnet speaker is to be preferred to an E.M. type on account of its greater freedom from hum. With our own DA30 amplifier, which we have had in operation since before the article was written, we use a single good quality 12 in. speaker in a vented baffle, and in spite of the fact that two speakers with a good dividing network would undoubtedly be preferable, we have been very much impressed with the performance of the combination, which sounds as clean and effortless as anything we have heard. If an E.M. speaker must be used, care should be taken to see that its field winding is NOT used as one of the smoothing chokes. While good enough for most purposes, this arrangement is not satisfactory with this amplifier. Our reason for saying so is simply that the residual hum in the amplifier itself is so low that even the small amount of hum introduced by using the speaker field as the second smoothing choke will quite overshadow that of the amplifier itself, which is inaudible when a P.M. speaker is used unless the ear is virtually touching the cone. The thing to do if an E.M. speaker is used is to give it a separate power supply for the field winding. This supply can have a condenser-input filter, and should have a smoothing choke as well, with a large electrolytic connected across the field winding.

* * *

A SUPERHET. RECEIVER USING TRIODES THROUGHOUT

R.M.D.G., Te Aroha, writes to inform us that he is using with considerable success the 6SN7 grounded-grid R.F. amplifier circuit published in "R. & E." in the March, 1947, issue. He wonders whether such a stage could usefully be employed as an I.F. amplifier, and has in mind a set with the following line-up:—6J6 R.F. amp., 6J6 osc. mixer, three stages of I.F. on 1600 kc/sec. using 6F8-G's or 6SN7's, 6SN7 combined infinite-impedance 2nd detector and noise-limiter, and 6SN7 B.F.O. He wants to know how the gain and selectivity of such a receiver would compare with those of a conventional communications receiver with two stages of I.F. at 465 kc/sec., and in addition, how A.V.C. can be incorporated in a receiver which has an infinite-impedance 2nd detector.

As R.M.D.G. says in his letter, one could expect the signal-to-noise ratio of such a line-up to be as high as it is possible to obtain, assuming that the aerial input circuit is properly designed, so that all one would need to worry about in the way of performance would be overall gain, selectivity, image ratio, and the ancillary matters such as A.V.C. and large-signal performance. First, in order to get optimum performance from the double-triode circuit as an I.F. amplifier, it would be desirable to use special I.F. transformers whose L/C ratio for the primary winding is rather different from that usually used with pentodes. It is for this reason, partly, that no use as an I.F. amplifier has yet been recommended in these pages. If special transformers are used, the selectivity could be made almost as good as that of a pentode stage working at the same frequency. However, it is doubtful whether there is anything to be gained by using any more than one triode I.F. stage, and that in the first stage. After this point even the weakest signal should have been brought up to a level where tube noise no longer governs the signal-to-noise ratio of the receiver. It would be preferable therefore to use two ordinary pentode stages after the triode first stage. These

would definitely give more overall gain than is strictly necessary, and could be run well below their maximum amplification, and used mainly from the point of view of selectivity. It should be remembered that a 1600 kc/sec. I.F. has inherently less selectivity than a low-frequency one, so that if a double-shift arrangement is not going to be used, the three stages would most probably be needed to get enough adjacent-channel selectivity.

With the high I.F., however, the image ratio of

(Continued on page 45.)

PUBLICATIONS RECEIVED

"Electronic Circuits and Tubes," by the War Training Staff of the Cruft Laboratory, Harvard University. Publishers, the McGraw-Hill Book Company, Inc., New York and London.

Since the end of the late world war there have appeared a number of excellent text-books covering the radio and electronic fields, produced by well-known educational institutions which have specialized during the war in the training of officers for the armed services. Although, as in the present case, the war-time course has differed considerably in content from the similar courses provided by the laboratory in peace-time, or perhaps because of this fact, the staff of lecturers, headed by Dr. E. L. Chaffee, have felt that the concentrated experience of the war years has contributed so much to the art of teaching electronic subjects that this book has been planned and written in order to pass on to students of the subject generally, the fruits of this experience.

As a result, this book contains not only much new material (new in the sense that it has not previously appeared in any text-book), but also displays a refreshingly new approach to a number of topics of fundamental importance. Perhaps the most noteworthy among these is the treatment of Class B and C amplifiers. It has always seemed to the writer that something is lacking in the normal text-book treatment of these important subjects, where the Class A amplifier is treated in detail, and Class B and C amplifiers are dealt with by the "analogy-with-a-difference" method. As the author of Chapter XIV, on Power Tubes, so rightly points out, the latter classes of amplifier operate under such widely differing conditions from those of the Class A case and the analogy is so difficult to sustain that there is small point in attempting to. The treatment of Class B and C amplifiers as "Power Converter Tubes," as they have been called by the author, by regarding the tube simply as a switch, should lead to a much readier appreciation and understanding by the student of the practical and theoretical significance of the rather numerous quantities involved. There is an admirably clear exposition of the graphical methods involved in designing such amplifiers, and also an excellent section which explains in detail the mechanisms of the time-honoured methods of adjustment so often taken for granted.

Among the new material is a chapter on timing circuits, which, when taken in conjunction with the earlier chapters on transients and Fourier analysis, forms a very fine introduction to the principles and practice of pulse technique, whose importance is growing rapidly, notwithstanding its rapid development during the war.

While the book is written on the assumption that the reader is reasonably well versed in mathematics and is definitely intended for the serious student, there is much valuable and interesting reading for those not so mathematically minded. A useful appendix, entitled "A Review of Mathematics," presents in shortened form much of the basic mathematical manipulations, an understanding of which is essential if the most is to be made of the material in the main portion of the book. A further appendix gives a similar review of the fundamental concepts of electricity and magnetism.

In short, this book forms a very worth-while addition to the existing range of text-books on vacuum tubes and their circuits, and one which might well replace some of the earlier works which have come to be regarded as standard, and which are now obsolescent, both in material and in treatment. Our copy has been received from the publishers.

* * *

Radio Data Charts, by R. T. Beatty, M.A., B.E., D.Sc.; fourth edition, revised by J. McG. Sowerby, B.A., Grad.I.E.E. Publishers, Iliffe & Sons, Ltd., London.

This is the second impression of the fourth edition of the late Dr. Beatty's well-known volume of data charts. This edition was originally published in 1945, and contains a considerable amount of new material which will be found as useful and time-saving as those charts which have now become standard.

There are now 144 charts altogether, covering such diversified problems as the design of iron-cored chokes and transformers, and the length of capacity-loaded quarter-wave transmission lines for use as resonant circuits in transmitters and receivers. Particularly useful to receiver designers are two of the new charts, relating to the design of I.F. transformers. The first of these is a series of universal selectivity curves, together with suitable scales, which enable the quantities Q, coupling coefficient, centre frequency, and response at any off-tune frequency, to be related. Thus, any one of these quantities can be found if the others are known. The universal curves enable the response of single circuits and double-tuned transformers to be found for values of kQ from 0.5 to 6, which is about the practical limit of overcoupling.

The other chart is for finding the value of the coupling coefficient, or the spacing required for a given coupling coefficient, for similar universal-wound coils whose dimensions are known.

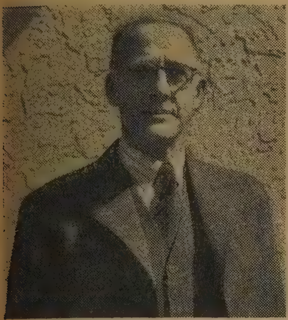
It should be emphasized that none of the charts requires any specialized knowledge for its application, and the pilot charts given on each one show with admirable clarity how each is manipulated, simply with the aid of a straight-edge.

In addition, excellent short explanations are given of the problems that can be solved by each chart, and these sections contain a considerable amount of valuable information. For instance, in the letterpress which explains the use of constant-impedance attenuators, there is a curve from which can be read the degree of additional attenuation caused by mismatching between either side of the attenuator and the load.

These brief remarks should be regarded as only illustrative, for the scope of the volume is too great for an enumeration to be made of all the problems that may be solved by its use. The book's greatest virtue is the way in which it can eliminate a great deal of the tedious arithmetical work involved in most design problems; those who are familiar with its previous editions will find it well worth having for the sake of the new material, and it can be warmly recommended to those who may not have seen it before.

OUR GOSSIP COLUMN

Mr. C. S. Gittoes, Technical Director of Ducon Condenser Ltd., of Australia, visited New Zealand recently in connection with the installation of plant in Ducon's New Zealand factory, now in operation.



Mr. W. G. Harrison

Mr. C. S. Gittoes

The Managing Director of Ducon (N.Z.) Ltd. is Mr. Wilfred G. Harrison, a well-known Wellington business man. His association with Ducon dates back to 1938 when negotiations were commenced for the establishment of a New Zealand factory. Unfortunately the war eliminated any possibility of the fruition of this project for some years. However, the time was not ill spent and the intervening period has provided ample opportunity for the careful planning of a production unit which will become an integral part of the electrical and electronic fields of New Zealand.

A more comprehensive story of Ducon's activities will be found in the "Trade Winds" section of this issue.

* * *

Messrs. H. S. and W. H. Pearson, of Te Kauwhata, called to see us recently. They were on a short business trip to Wellington prior to proceeding to Christchurch to attend a wedding.

* * *

A recent company registration was that of W. G. Leatham Ltd. Guy Leatham, who is well known in the radio and electrical field, is concentrating on electrical merchandise of all types and electronic test equipment. The company still retains the original address—Box 11, Lower Hutt—but an additional address is Box 1284, Wellington.

* * *

MR. G. A. WOOLLER'S TRIP TO AMERICA

Three months was spent on business affairs in the United States recently by George Wooller of G. A. Wooller & Co., Ltd. His comments on the trend of business there indicate that American business men are generally confident that trade will remain at a good level for at least three years. This is despite the fact that the American market appears to have a surplus of radio sets. With business settling back to a normal pre-war competitive level (as appears to be the case here in New Zealand just now) there have, of course, been the inevitable cases of "war babies" going to the wall. One result of this is that

retailers are selling many sets at prices extremely low by New Zealand standards. George points out that before the war there were only approx. 35 recognized radio manufacturers in the States, but this figure grew to over 300 during the war. For some of these newer firms, accustomed only to the boom trading of the war years, the return to normal competitive selling offers qualms which are not shared by older and experienced manufacturers who know what it means and "takes" to get out and **sell.**

George Wooller speaks very highly of the services given by the New Zealand trade Commissioners in Washington and Montreal. He was greatly helped by the fact that they were up to date with all the latest information he sought and in many other respects he found them obliging and able to give help to their New Zealand compatriots. Bob Marshall, Percy Cronin, John Scott, and Ken Futter in Washington and Joe Malcolm in Montreal are five officials who can be extremely helpful to others who may have occasion to visit the United States and Canada on business.

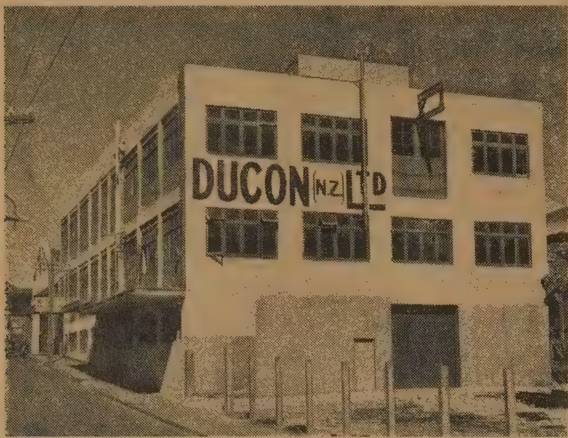
In the course of a comprehensive tour of key centres of radio manufacturing in the States, George visited plants in Boston, Buffalo City, Emporium, Cleveland, Cincinnati, San Francisco, and New York. He also attended the National Electronics Convention at Edgewater Beach Hotel, Chicago, and the National Lighting Exhibition at the Stevens Hotel, Chicago. Several agency agreements were completed. A good deal of time was spent in New York which is the export centre of the radio industry and has, of course, a special interest for G. A. Wooller & Co., Ltd., insofar as New York is the location for the International division of Sylvania Electric Products Inc. Whilst there he ran into J. R. Robertson (N.Z. Industries Ltd.), Hugo Johnson (Johnson Cardboard Box Co.), and Tom Dowdle (Empire Box Co.).

George Woollers's strongest impression of the States is the efficient manner in which the Americans do business and in particular their cordiality towards business people from other countries.

TRADE WINDS

In this issue we announce the formation in New Zealand of a company, Ducon (N.Z.) Ltd., a subsidiary controlled by Ducon Condenser Ltd., of Sydney. The Managing Director of Ducon (N.Z.) Ltd. is Mr. Wilfred G. Harrison, a well-known business man of 21 Grey St., Wellington.

Ducon (N.Z.) Ltd. is already in production on certain types of paper dielectric condensers and production is commencing within the next few days of electrolytic condensers. It is intended that this plant will produce a full range of paper and electrolytic type condensers required by the radio manufacturing and servicing trades, the Post and Telegraph Dept., broadcasting services, and the electrical manufacturing industries. A large amount of plant is already installed and further plant will arrive and be installed in the near future. As a subsidiary of Ducon Condenser Ltd. of Australia, this company will have available to it all of the technical and developmental resources of the Australian company.



Messrs. Ducon (N.Z.) Ltd.'s premises in Wellington.

Ducon Condenser Ltd. of Australia has been manufacturing since 1932 and produces every type of static condenser at present being used. The operations of the Australian company are conducted in two plants, one at Waterloo, Sydney, where 550 hands are employed in premises having a floor space of approximately 70,000 square feet. Another plant is operated in the country district west of Sydney called St. Marys where a further 250 hands are employed in premises having a floor space of 27,000 square feet. It is expected that Ducon (N.Z.) Ltd. will employ approx. 150 people in the manufacturing of condensers in New Zealand.

Behind the Australian organization is a wealth of strength in regard to technical, developmental, and research work. Over and above its own laboratories where chemists and engineers are employed stand several major overseas companies with whom manufacturing agreements are operated. These overseas companies include organizations such as the General Electric Co. of America by whom Ducon Condenser Ltd. are licensed under several patents covering Australia and New Zealand, the principal one being the use of synthetic dielectric such as pentachlordiphenol, which is commonly known among electrical engineers as "Pyranol." The General Electric Co. are well known throughout the world as leaders in the industrial condenser field, and by arrangement with this company continuing research and development is available to Ducon in Australia and New Zealand. Ducon also operates similar manufacturing agreements with organizations such as the Western Electric Co., behind which stands the Bell Telephone

(Concluded on page 46.)

RADIO RECEIVER POWER SUPPLIES

(Continued from page 27.)

densers having limited radiation facilities, the losses produced by the added series resistance as indicated by a high power factor may be sufficient to raise the temperature of the condenser sufficiently high to affect its characteristics. The effect of temperature is to increase the leakage current of the condenser. A high power factor condenser, therefore, introduces a condition which is cumulative in its effect, the higher power factor causing a greater temperature and the increased temperature causing still higher losses.

The curves of Figs. 24 and 25 were included to show the effect of two different transformers, one being a transformer liberally designed and properly engineered and the other being a transformer of much cheaper construction. These curves are of interest inasmuch as they show the effect of transformer regulation on the characteristics of the filter. The curves are self-explanatory. It is interesting to note the effect of the input capacity on the D.C. filter output voltage of the two transformers used. The output voltage for transformer No. 1 increases from about 230 volts to 315 volts at an input capacity of 7 mfd. and thereafter remains constant. For the transformer No. 2 the voltage increases from 170 volts at 1 mfd. to 210 volts at 4 mfd. and thereafter remains constant. The difference in the output voltages for the two transformers, although each transformer is rated at 300 volts, either side of the centre tap, is due to the poorer regulation of the cheaper transformer. After the capacity reaches a value at which the voltage becomes constant, further increases in capacity do not affect the output voltage as the voltage drop across the condenser becomes smaller, thus counteracting the greater tube drops caused by the increased peak tube currents, and the voltage drop of the transformer.

These curves illustrate graphically the various conditions that exist in typical rectifier circuits. Using this information, it is possible to determine the action of a rectifier under various conditions of load and filter circuits. It should be noted that the action of the rectifier tube depends on the type of filter input circuit, and not only is the D.C. output voltage determined by the filter used but the ripple output voltage is also greatly affected by the filter circuit. The filter circuit used determines both the A.C. ripple input to the filter and the ripple attenuation in the filter. The peak plate current is also determined by the type filter circuit used, and for tubes having a low impedance drop, condenser input filters should not be used, as the peak plate currents rise rapidly with a decrease in the tube impedance. Large tube current not only decreases the life of the tube but also increases the heating of the plate supply transformer, necessitating the use of a larger transformer to deliver a given D.C. output. There is very little to be gained by the use of excessively large input filter condensers, as the D.C. voltage does not increase materially after capacities greater than 8 to 10 mfd. have been reached.

CLASSIFIED ADVERTISEMENT

WESTREX TEST INSTRUMENTS

(Continued from page 15.)

phototube and horns, replacing an entire amplifier system and power supplies. This amplifier provides sufficient power to operate the largest theatres on an emergency basis.

With this modern equipment and instruction on its use, Western Electric engineers will be even better qualified to maintain the equipment of motion picture theatres in excellent working condition. In the event of an emergency failure, the new facilities will make for faster, more accurate checks and less time loss through shut-downs for repairs, while routine checks, tune-ups, and repairs can be made rapidly and accurately. With a continuous development programme under way in their laboratories, Westrex plans to keep its equipment and engineers up to the minute in order to maintain high standards of service to motion picture exhibitors.

QUESTIONS AND ANSWERS

(Continued from page 39.)

the receiver will be much better than that of the one with the low I.F., and can be considered adequate for all frequencies up to 30 mc/sec.

If A.V.C. is wanted with this line-up, it would be necessary to add a diode, since the infinite-impedance detector will not produce a negative D.C. voltage suitable for A.V.C. control purposes. This diode rectifier could be fed from the plate of the last I.F. stage through a small condenser, in the same way as the A.V.C. diode of many domestic sets.

A Practical Beginners' Course

PART 20

OPERATING THE SHORT-WAVE SET

First of all, it must be pointed out that the principle of the set as now modified is exactly the same as before. The reaction control works (or should do) in just the same way, and the detector is set oscillating in the same way as before, in order to find weak signals. The first thing to do when the set has been switched on is to see that it will oscillate. If there is any uncertainty about this, a good test is to touch the grid terminal of the valve momentarily with the finger. If the set is oscillating, there will be a pronounced "plop" both when the finger is touched on, and when it is removed. If this double plop is not heard, the set can be assumed not to be oscillating. If it is not, the most likely reason is that one of the connections to the coils has been reversed. You will remember that Fig. 28 has been drawn so as to represent the correct coil connections if all windings are in the same direction. That is to say, when the top of the grid winding is connected to the grid condenser and grid-leak, the bottom of the reaction coil must be connected to the plate. If the top of the latter coil is taken to the plate by mistake, the feedback is no longer in the correct direction to cause regeneration, and the detector will not oscillate. The cure for this state of affairs is obviously to reverse the connections to either the grid-coil or to the reaction coil, BUT NOT TO BOTH. If this were done, we would end up with the same condition as that with which we started. With this circuit, the only other likely reason for non-oscillation is that the reaction coil has not enough turns, or is not placed close enough to the grid-coil. The most likely fault is not that of oscillation being impossible to obtain (if the connections are made the right way round) but that it will be quite satisfactory over part of the tuning range, but will not occur over other parts. This behaviour may be due to the use of too large an aerial. If it is found, the aerial should be disconnected, and the set again tried for oscillation. If it is now obtained over the whole dial, the aerial is the cause, and shortening it will effect a cure. If it is not desired to do this, one can do just as well by connecting a very small condenser in series with the aerial, or, in other words, between the aerial terminal and the top of the aerial coil. The size of this condenser is not critical, and any of the small pre-set types that are used for trimming condensers in large receivers will do quite well. These usually have a maximum capacity of 30 mmfd., and can be used at full capacity. Alternatively, a fixed condenser of 50 mmfd. should be quite satisfactory. Of course, if the length of aerial is not causing trouble, the lack of oscillation will be in evidence even after the aerial has been disconnected. The usual effect is that the set oscillates quite well at the high-frequency end of the tuning range, but as the tuning condenser is moved in, more and more reaction condenser has to be used to maintain oscillations, until a point is reached where the reaction condenser is all in, and yet the set will not oscillate over the lowest frequency part of the tuning dial. The cure for this is to slide the reaction coil a little nearer to the grid-coil. If this improves matters, but still leaves a small gap at the low-frequency end of the range, it is necessary to add a turn or two to the reaction coil. It might be thought that this is a simple matter, and that it is only a question of adding turns to this coil until a stage is reached where oscillation is had over the whole dial. The only trouble with this argument is that if too many turns are put on the reaction coil, a different fault shows up: the set becomes uncontrollable at the high-frequency end of the range, and will do nothing BUT oscillate! This is a very good demonstration of a kind of thing that we will find in a great many places in radio work. Very often there is not an absolutely clear-cut solution to a problem, because the method of solution can itself introduce an entirely new problem. As a result, the correct answer is one which steers a middle course between the two problems, and avoids both either by a careful choice of component values, or by careful adjustment.

When a little experience has been gained in handling this first shortwave set, one most noticeable feature will be apparent. It is this, that where in the broadcast version it is relatively easy to tune each station, this is not so in the shortwave version.

This difficulty is due mainly to the fact that on the shortwave set there is room for so many more stations that each one occupies only a fraction of the dial space taken up by a station on the broadcast band.

Now, any station has a single, fixed carrier frequency, and it might be supposed that irrespective of whether that frequency is high or low, the station would occupy the same amount of space on the dial. This is not so, however, and the reason for it may be explained as follows:—

Every station takes up a certain amount of "space" on the air; that is to say, it requires not only the single frequency of its carrier, but also a small **band** of frequencies on either side of this. The width of this band is related in a simple fashion to the highest modulation or audio frequency that it is desired to transmit. For example, if we wish to transmit all audio frequencies up to 10,000 c/sec., our transmitter will cover a frequency range of plus **and** minus 10 kc/sec. from the carrier frequency.

TRADE WINDS

(Continued from page 44.)

Laboratories of America; also P. R. Mallory and Co. of Indianapolis, U.S.A., the Aerovox Corporation of New Bedford, U.S.A., the Erie Resistor Corp. of Erie, U.S.A., and General Ceramics and Steatite Corp. of New Jersey, U.S.A.

The wealth of research, developmental work, and engineering information accruing from these associations places the Ducon Co. in both Australia and New Zealand in a favourable position in respect to those products and it is stated that no other condenser manufacturing organization in the world has such a collective aggregation of technical knowledge available.

During the recent war the Ducon Co. in Australia was able to perform a national service and supplied the condenser requirements of the Forces operating in the South-west Pacific area and it is obvious that the operation of a condenser manufacturing plant in New Zealand is of definite value to the Dominion for the same reason.

The plant at present being set up and operated by Ducon (N.Z.) Ltd. is in charge of its Works Manager, Mr. D. Selfe, who recently arrived in New Zealand from the Australian plant. The names of additional personnel will be released at a very early date.

Index to Radio and Electronics, Vol. 2

EDITOR'S NOTE

We regret that the exigencies of space prevent us from publishing the index to Vol. II of "Radio and Electronics" completely in this issue. Readers will note, however, that we have placed the above section in such a position as to make its removal possible without harming any of the remainder of the contents of the issue. Letters R to Z of the index will appear in the June, 1948, issue, on page 48, so that those who wish may still make up a complete and separate index for our second volume.

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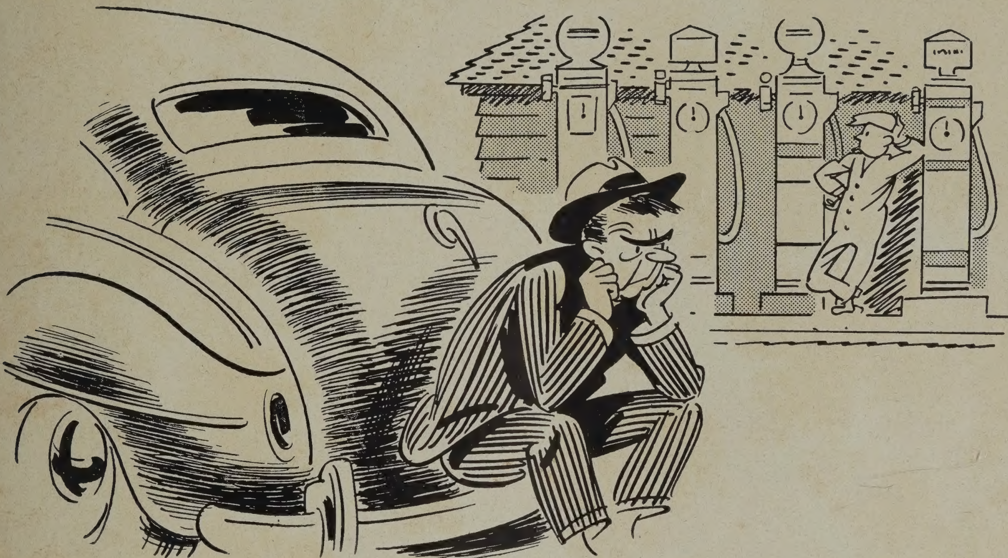
Like a motor car without petrol . . .



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